Federal Aviation Administration – Regulations and Policies
Aviation Rulemaking Advisory Committee

Transport Airplane and Engine Issue Area
Powerplant Installation Harmonization Working Group

Task 7 – Powerplant Inflight Restarting

Task Assignment

[Federal Register: September 23, 1998 (Volume 63, Number 184)]
[Notices]
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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine Issues--New Tasks

AGENCY: Federal Aviation Administration (**FAA**), DOT.

ACTION: Notice of new task assignments for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: Notice is given of new tasks assigned to and accepted by the Aviation Rulemaking Advisory Committee (ARAC). This notice informs the public of the activities of ARAC.

FOR FURTHER INFORMATION CONTACT: Stewart R. Miller, Transport Standards Staff (ANM-110), Federal Aviation Administration, 1601 Lind Avenue, SW., Renton, WA 98055-4056; phone (425) 227-1255; fax (425) 227-1320.

SUPPLEMENTARY INFORMATION:

Background

The **FAA** has established an Aviation Rulemaking Advisory Committee to provide advice and recommendations to the **FAA** Administrator, through the Associate Administrator for Regulation and Certification, on the full range of the **FAA**'s rulemaking activities with respect to aviation-related issues. This includes obtaining advice and recommendations on the **FAA**'s commitment to harmonize its Federal Aviation Regulations (FAR) and practices with its trading partners in Europe and Canada.

One area ARAC deals with is Transport Airplane and Engine Issues. These issues involve the airworthiness standards for transport category airplanes and engines in 14 CFR parts 25, 33, and 35 and parallel provisions in 14 CFR parts 121 and 135.

The Tasks

This notice is to inform the public that the **FAA** has asked ARAC to provide advice and recommendation on the following harmonization tasks:

Task 5: Power Plant Fire Mitigation Requirements

Specific Tasks--Phase I

1. Rule Harmonization

(a) JAR 25.1183 has a (c) paragraph that adds the requirement for components to be fireproof where, if damaged, fire could spread or essential services could be adversely affected.

(b) FAR/JAR 25.1187, 25.1189(a) and 25.1193(c) are considered equivalent--no harmonization is required.

2. Advisory Material (AC/AMJ) Harmonization

(a) FAR 25.1187--Drainage and Ventilation of Fire Zones. **FAA** regulation requires the provisions for flammable fluid drainage, including the drainage path and drainage capacity, be demonstrated to be effective under anticipated conditions. Draft AC 25.1187, published for comments, describes the methodology to be used. **FAA** and JAA agreement on an acceptable means of demonstrating compliance is required. The Advisory Material to be developed should provide guidance on an acceptable means of demonstrating compliance for ``drainage of flammable fluids''.

(b) FAR 25.1189(a)--Shutoff Means. This paragraph requires shutoff valves to prevent a hazardous quantity of flammable fluid entering a fire zone following detection of a fire. The central issue to be resolved is associated with **FAA**/JAA agreement of the definition of ``hazardous quantity'' of flammable fluid. The working group should provide guidance to the **FAA** and JAA to define what is considered a ``Hazardous Quantity of Flammable Fluid'' when showing compliance to this regulation.

(c) FAR 25.1193(c)--Cowling and Nacelle Skin. **FAA** requires the nacelle be fireproof for 360 degrees, unless aerodynamic testing shows that fire exiting the nacelle poses no additional hazards to the airframe. JAA reportedly accepts 90 degrees (45 degrees from pylon centerline) without additional testing. JAA NPA proposes to provide guidance (JAA PNPA 25E-266). **FAA** and JAA should document current practices for use by Task Group consideration towards development of harmonized guidance regarding this subject. The Guidance Material to be developed should provide guidance on an acceptable means of demonstrating that the extent of fire proof cowling assures ``no additional hazard to the airframe'' for all types of transport category airplane engine installations.

The **FAA** expects ARAC to submit its recommendation(s) resulting from Phase I by November 30, 2000.

Specific Tasks--Phase II

1. Rule Harmonization

(a) Harmonize the definitions of the terms ``fire resistant'' and ``fire proof'' in FAR 1 and JAR 1.

2. Advisory Material (AC/AMJ) Harmonization

(a) Draft additional advisory material for 25.903(d)(1) related to minimizing the hazard associated with engine case burnthrough.

(b) Validate and harmonize the Fire Test Guidance Material in Paragraph 8 of AC 20-135 (may be transferred to be included in burnthrough advisory material).

(c) Validate and Harmonize the FAR/JAR Advisory Material for Engine Case Burnthrough and/or Related Engine Fire Test Guidance material such as an ISO standard.

The **FAA** expects ARAC to submit its recommendation(s) resulting from Phase II by April 1, 2001.

Task 6: Prohibition of Inflight Operation for Turbopropeller Reversing System and Turbojet Thrust Reversing System Intended for Ground Use Only

Recommend harmonized changes to FAR/JAR 25.1155 which would require a means to prevent the flight crew of turbine powered airplanes from inadvertently or intentionally placing the propellers into beta, deploying the thrust reverser while inflight, or otherwise commanding reverse thrust, unless the airplane has been certified for such operation. In addition to the harmonized rule recommendation, harmonized advisory material may also need to be developed in order to further standardize compliance with the recommended rule.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by July 31, 2001.

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Task 7: Powerplant Inflight Restarting

Review FAR 25.903(e) and corresponding JAR requirement related to inflight restarting and generate an amended harmonized requirement that provides a minimum engine restart capability within the airplane operating envelope following loss of all engine thrust. In addition, provide harmonized advisory material that defines the acceptable methods of compliance to the amended regulations. Both of these tasks should take into account and address:

1. Review of the service history.
2. Review of inherent starting capability of the engines at the time the original 25.903(e) rule was promulgated.
3. Alternative design means for restarting main engines.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by July 31, 2001.

The **FAA** requests that ARAC draft appropriate regulatory documents with supporting economic and other required analyses, and any other related guidance material or collateral documents to support its recommendations. If the resulting recommendation(s) are one or more notices of proposed rulemaking (NPRM) published by the **FAA**, the **FAA** may ask ARAC to recommend disposition of any substantive comments the **FAA** receives.

Working Group Activity

The Powerplant Installation Harmonization Working Group is expected to comply with the procedures adopted by ARAC. As part of the procedures, the working group is expected to:

1. Recommend a work plan for completion of the tasks, including the rationale supporting such a plan, for consideration at the meeting of ARAC to consider transport airplane and engine issues held following publication of this notice.
2. Give a detailed conceptual presentation of the proposed recommendations, prior to proceeding with the work stated in item 3 below.
3. Draft appropriate regulatory documents with supporting economic and other required analyses, and/or any other related guidance material or collateral documents the working group determines to be appropriate; or, if new or revised requirements or compliance methods are not recommended, a draft report stating the rationale for not making such recommendations. If the resulting recommendation is one or more notices of proposed rulemaking (NPRM) published by the **FAA**, the **FAA** may ask ARAC to recommend disposition of any substantive comments the **FAA** receives.
4. Provide a status report at each meeting of ARAC held to consider

transport airplane and engine issues.

The Secretary of Transportation has determined that the formation and use of ARAC are necessary and in the public interest in connection with the performance of duties imposed on the **FAA** by law.

Meetings of ARAC will be open to the public. Meetings of the Powerplant Installation Harmonization Working Group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on September 17, 1998.

Joseph A. Hawkins,
Executive Director, Aviation Rulemaking Advisory Committee.

[FR Doc. 98-25469 Filed 9-22-98; 8:45 am]
BILLING CODE 4910-13-M

Recommendation Letter

Approp Action ARM

400 Main Street
East Hartford, Connecticut 06108

Pratt & Whitney
A United Technologies Company

October 23, 2000

Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Attention: Mr. Thomas McSweeny, Associate Administrator for Regulation and Certification

Subject: Submittal of ARAC Recommendations

Reference: FAA Tasking to TAEIG, dated November 19, 1999.

Dear Tom,

In accordance with the reference tasking, the ARAC Transport Airplane and Engine Issues Group is pleased to forward the attached "Fast Track" report for 25.1193(e) to the FAA as an ARAC recommendation. This report has been prepared by the Powerplant Installation Harmonization Working Group of TAEIG.

TASK 5 PART C.

Sincerely yours,

C. R. Bolt

C. R. Bolt
Assistant Chair, TAEIG

copies: *Andrew Lewis-Smith - Boeing
Kristin Carpenter - FAA
*Effie Upshaw - FAA

*letter only

CRB_10_23_00

Recommendation

Final Draft, July 7, 2000 , updated September 18, 2000
For Submittal to TAEIG

ARAC WG Report Format
For §25.1193(e) Cowl Skin Fire Protection

1 - What is underlying safety issue addressed by the FAR/JAR? [Explain the underlying safety rationale for the requirement. Why does the requirement exist?]

Prevention of hazards caused by a fire within an engine or APU fire zone burning through the fire zone external skin or exiting through a skin opening.

2 - What are the current FAR and JAR standards? [Reproduce the FAR and JAR rules text as indicated below.]

Current FAR text:

§ 25.1193 Cowling and Nacelle Skin.

(e) Each airplane must-

(1) Be designed and constructed so that no fire originating in any fire zone can enter, either through openings or by burning through external skin, any other zone or region where it would create additional hazards;

(2) Meet paragraph (e)(1) of this section with the landing gear retracted (if applicable); and

(3) Have fireproof skin in areas subject to flame if a fire starts in the engine power or accessory sections.

Note: Also applies to equivalent APU regulations contained in proposed appendix K to FAR 25, Para K1193(e).

Current JAR text:

Same, except for spelling of "aeroplane" versus "airplane."

Note: Also applies to equivalent APU regulations contained in JAR 25, Subpart J, Para 25A1193(e).

3 - What are the differences in the standards and what do these differences result in?: [Explain the differences in the standards, and what these differences result in relative to (as applicable) design features/capability, safety margins, cost, stringency, etc.]

There are no differences in the standards.

4 - What, if any, are the differences in the means of compliance? [Provide a brief explanation of any differences in the compliance criteria or methodology, including any differences in either criteria, methodology, or application that result in a difference in stringency between the standards.]

FAA policy requires, for pod mounted engines, that 180 degrees of nacelle skin centered on the strut or pylon, be fireproof unless specific substantiation of fire/fluid path from a burn-through shows that a lesser coverage (minimum of 90 degrees) will not create a hazard. The policy clearly refers to flight conditions but not to ground conditions, however, these are intended to be included.

JAA policy, as stated and applied per NPA 266, requires that:

- The entire nacelle skin be fireproof in flight, with consideration for external airflow.
- Those portions of the nacelle from which a burn-through could affect critical airplane systems or structure, expressed as pylon side area for pod mounted engines, be fireproof during ground operations.
- Other areas of the nacelle where a burn-through could hazard passenger evacuation be demonstrated to be fire resistant during ground operation.
- Remaining portions of the nacelle do not have a specific requirement.

5 – What is the proposed action? [Is the proposed action to harmonize on one of the two standards, a mixture of the two standards, propose a new standard, or to take some other action? Explain what action is being proposed (not the regulatory text, but the underlying rationale) and why that direction was chosen.]

FAR/JAR 25.1193(e) will be revised to clarify apparent inconsistency between 25.1193(e)(1) objective requirements and 25.1193(e)(3) prescriptive requirements, to avoid inconsistency between rule language and policy or advisory material, and to address acceptable differences in requirements for flight and ground operation.

Draft advisory material will be provided addressing acceptable means of compliance, and enveloping FAA and JAA policy for ground conditions.

6 - What should the harmonized standard be? [Insert the proposed text of the harmonized standard here]

§ 25.1193 Cowling and Nacelle Skin.

(e) Each airplane must-

(1) Be designed and constructed so that no fire originating in any fire zone can enter, either through openings or by burning through external skin, any other zone or region where it would create additional hazards; (Note: (e)(1) unchanged)

(2) Meet paragraph (e)(1) of this section with the landing gear retracted (if applicable); and (Note: (e)(2) unchanged)

(3) For in-flight operation from V1 to minimum touchdown speed, have fireproof skin in areas subject to flame if a fire starts in an engine fire zone, and for ground operation have fireproof skin in areas where a skin burn through would effect areas of the airplane critical for ground operation, and have skin which is either fire resistant or complies with (e)(1) in other areas.

7 - How does this proposed standard address the underlying safety issue (identified under #1)? [Explain how the proposed standard ensures that the underlying safety issue is taken care of.]

The proposed standard addresses the underlying safety issue by maintaining existing 25.1193(e)(3) prescriptive requirements for in-flight operations where a skin burn-through could have the greatest hazard potential, and by relying on existing 25.1193(e)(1) objective requirements, which are considered to contain the basic intent of the regulation, for ground operations where the hazard potential of a skin burn-through may be lower.

8 - Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain. [Explain how each element of the proposed change to the standards affects the level of safety relative to the current FAR. It is possible that some portions of the proposal may reduce the level of safety even though the proposal as a whole may increase the level of safety.]

The proposed standard provides an equivalent level of safety to the existing FAA and JAA interpretations of the regulations. The FAA has interpreted the current standard by a variety of Issue Papers, which have been summarized in the Draft Propulsion Mega-AC (under Section 25 1193 material). The JAA has interpreted the standard per NPA E-266, which has been applied as a Certification Review Item on numerous applications for many years. The proposed standard is a compilation of the most conservative aspects of existing FAA and JAA policies and industry practices. A review of service experience, involving several hundred ground and flight fires in Transport Category airplanes from 1982 through 1999 has demonstrated that these practices have provided an acceptable level of safety.

9 - Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain. [Since industry practice may be different than what is required by the FAR (e.g., general industry practice may be more restrictive), explain how each element of the proposed change to the standards affects the level of safety relative to current industry practice. Explain whether current industry practice is in compliance with the proposed standard.]

Relative to current industry practice, the proposed standard and advisory material maintains current level of safety.

Consideration has been given as to the safety effects in relationship to fire detection and extinguishing capability. It is concluded that the proposed standard and advisory material will retain at least the existing level of safety for the following reasons:

- The requirement for complete skin fireproofness in flight, which is most critical with respect to fire protection, will prevent impairment of these functions due to skin burn, through.
- Advisory material will specify fire resistance under ground conditions in those areas where a burn-through would adversely affect fire detection capability, thus maintaining consistency with FAR/JAR 25.1103(e) requirements.
- Advisory material will specify fire resistance under ground conditions in those areas where a burn-through would adversely affect fire extinguishing capability. This will not result in a decrease in safety due to the fact that fire extinguishing is not relied on to the exclusion of other protection means such as flammable fluid shutoff means, firewall integrity, and for ground operation, passenger evacuation. Additionally, a skin burn-through during ground operation is considerably less likely to affect fire extinguishing capability than it would be in flight, due to much lower external and internal air flow rates.

10 - What other options have been considered and why were they not selected?: [Explain what other options were considered, and why they were not selected (e.g., cost/benefit, unacceptable decrease in the level of safety, lack of consensus, etc.]

Option	Reason for Not Selecting
Delete 25.1193(e)(3) in favor of 25.1193(e)(1), which is a more objective and less prescriptive requirement.	Subjectivity could lead to inconsistent interpretations and resulting effects on safety.
Require strict compliance with existing 25.1193(e)(3), requiring fireproof skin without exception.	Not necessary for safety or consistent with long standing policy and practice with extensive service experience,
Provide advisory material enveloping existing policy and means of compliance, without a rule change.	Advisory material could be considered as improperly lessening the rule requirements.
Complete enveloping of the rules and policy	The existing FAA and JAA regulations have been interpreted by Issue Papers (FAA) and Certification Review Items(JAA) for many years. The task group considered it to be more beneficial to recommend the proposed changes to the rule in order to clearly reflect the existing FAA and JAA interpretations.
Delete required consideration of passenger evacuation per JAA policy, based on alternate evacuation route availability, lesser criticality compared to other evacuation scenarios, etc.	Unlikely to obtain harmonization due to differences, Task Group does not have necessary expertise or authority to address cabin safety issues.
Provide more specific criteria as to hazards to evacuation, such as acceptable proximity to evacuation routes, number of routes affected, etc.	Task Group does not have necessary expertise or authority to address cabin safety issues.
Provide more specific criteria for engines/APUs which are not pod mounted.	The variety of configurations and possible burn-through hazard potential does not lend itself to specific criteria. Case by case evaluation is more appropriate.
Provide Advisory Material addressing 25.1193(e)(2) requirement specifying applicability with landing gear retracted.	Neither TOR nor Task Group discussion disclosed a need for Advisory Material.

11 - Who would be affected by the proposed change? [Identify the parties that would be materially affected by the rule change – airplane manufacturers, airplane operators, etc.]

Aircraft manufacturers and other manufacturers involved in the design, testing, and certification of nacelles or other fire zone enclosures.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble? [Does the existing advisory material include substantive requirements that should be contained in the regulation? This may occur because the regulation itself is vague, or if the advisory material is interpreted as providing the only acceptable means of compliance.]

Current advisory material and policy includes JAA NPA-266, and FAA policy letters contained in the Draft FAR 25 Propulsion Mega-AC. Also, reference AC 20-135. A new Draft AC/ACJ has also been prepared. The following important elements of the draft AC/ACJ are appropriate for discussion in the preamble:

- Applicability to fire zone fires defined in AC 20-135 (or ISO 2865) (or proposed harmonized FAR 1/JAR 1) but not to engine case burn-through events covered separately under FAR/JAR 25.903(d)(1).
- Requirement for skin fireproofness in flight (from V1 to touchdown) with consideration for external airflow).
- Requirement for skin fireproofness on ground in critical areas where burn-through could result in explosion, significant spread of fire, or fuselage penetration. Critical areas for pod mounted engines defined to typically include from 90 to 180° of coverage, depending on specific installation.
- Requirement for fire resistant cowling on ground in less critical areas where burn-through could impair personnel evacuation, fire detection, or fire extinguishing.
- Requirement for skin fire withstanding capability equivalent to .040" (1.0 mm) aluminum in remaining areas not requiring fireproof or fire resistant skin.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted? [Indicate whether the existing advisory material (if any) is adequate. If the current advisory material is not adequate, indicate whether the existing material should be revised, or new material provided. Also, either insert the text of the proposed advisory material here, or summarize the information it will contain, and indicate what form it will be in (e.g., Advisory Circular, policy, Order, etc.)]

No published FAA advisory material exists. Existing policy and draft advisory material is not adequate due to lack of harmonization with JAA policy and lack of clear differentiation between ground and flight requirements. Proposed new advisory material is attached.

14 - How does the proposed standard compare to the current ICAO standard? [Indicate whether the proposed standard complies with or does not comply with the applicable ICAO standards (if any)]

Unknown.

15 - Does the proposed standard affect other HWGs? [Indicate whether the proposed standard should be reviewed by other harmonization working groups and why.]

Cabin safety working group awareness of egress considerations may be advisable.

16 - What is the cost impact of complying with the proposed standard? [Is the overall cost impact likely to be significant, and will the costs be higher or lower? Include any cost savings that would result from complying with one harmonized rule instead of the two existing standards. Explain what items affect the cost of complying with the proposed standard relative to the cost of complying with the current standard.]

Relative to compliance with the existing rule, this change would reduce the cost, however relative to current practice, no significant cost change is expected for many applications. Some applicants may incur a minor cost increase due to either increased substantiation efforts, or application of existing skin fire protection methods over a larger nacelle area.

17 - Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

Yes.

18 – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process. Explain. [A negative answer to this question will prompt the FAA to pull the project out of the Fast Track process and forward the issues to the FAA's Rulemaking Management Council for consideration as a "significant" project.]

The HWG considers that the "Fast Track" process is appropriate.

Attached is further technical discussion and proposed advisory material in the form of a draft AC/ACJ.

RESISTANCE TO FIRE OF NACELLE COWLINGS
PPIHWG Fire Protection Task Group -Final Draft
Feb 2, 2000

1. PARAGRAPH AFFECTED

FAR/JAR 25.1193 (e)

2. PROPOSAL

Add an AC/ACJ with following wording:

AC/ACJ 25.1193 (e)
Resistance to fire of Nacelle Cowlings (Acceptable Means of Compliance)
See FAR/JAR 25.1193 (e)

One, but not the only, acceptable means of showing compliance with Jar 25.1193(e) is as follows:

I. Regulatory History

To be added by FAA

II. Background

- Requirement originally developed for piston engine aircraft.
- Applicability to turbine engine aircraft has developed over the years to provide equivalent level of safety. The most recent FAA and JAA policy is:

  FAA policy requires, for pod mounted engines, that 180 degrees of nacelle skin centered the strut of pylon, be fireproof unless specific substantiation of fire/fluid path from a burn-through shows that a lesser coverage (minimum of 90 degrees) will not create a hazard. The policy clearly refers to flight conditions but not to ground conditions, however, these are intended to be included.

  JAA policy, as stated and applied per NPA 266, requires that:
  - The entire nacelle skin be fireproof in flight, with consideration for external airflow.
  - Those portions of the nacelle from which a burn-through could affect critical airplane systems or structure, expressed as pylon side area for pod mounted engines, be fireproof during ground operations.
  - Other areas of the nacelle where a burn-through could hazard passenger evacuation be demonstrated to be fire resistant during ground operation.
  - Remaining portions of the nacelle do not have a specific requirement.

<u>III. Applicability</u>

This advisory material addresses the engine nacelle fire zone skin and APU compartment fire zone skin requirements of FAR/JAR 25.1193 (e), which reads as follows:

> (e) Each airplane must--
>
> (1) Be designed and constructed so that no fire originating in any fire zone can enter, either through openings or by burning through external skin, any other zone or region where it would create additional hazards;
>
> (2) Meet sub-paragraph (e)(1) of this paragraph with the landing gear retracted (if applicable); and
>
> (3) For in-flight operation from V1 to minimum touchdown speed, have fireproof skin in areas subject to flame if a fire starts in an engine fire zone, and for ground operation have fireproof skin in areas where a skin burn through would effect areas of the airplane critical for ground operation, and have skin which is either fire resistant or complies with (e)(1) in other areas.

This advisory material also addresses the equivalent APU fire zone external skin requirements contained in FAR 25, Appendix K, Para. K1193(e), and JAR 25, Subpart J, Para. 25A1193(e).

II. Fire Barrier Requirements, Operating Conditions, and Potential Hazards.

A. General

The required level of ability to withstand the effects of fire varies with the potential hazard level associated with different flight and ground operating conditions, as follows:

B. Flight Conditions

For flight conditions from airspeed above V1 until minimum touchdown speed in approved normal or abnormal operations, the skin in areas subject to flame if a fire starts in an engine or APU fire zone shall be demonstrated to be fireproof. The conditions for demonstrating the fireproof capabilities of the cowling should be consistent with the critical operating conditions. Where engine power can affect conditions on the cowling (including max engine power, min engine power and propeller feathering), these should be examined and the most critical determined. These conditions should be applied for 5 minutes, with the remaining 10 minutes under engine windmilling conditions.

C. Ground Conditions.

1. Engine Operation Requirements for ability of skin in areas subject to flame if a fire starts in an engine or APU fire zone to withstand the effects of fire under ground operating conditions apply with either the engine operating or not operating, whichever is the more critical.

2. Nacelle areas where fireproof skins are required - The portion of skin in areas subject to flame if a fire starts in an engine or APU fire zone, and located so that a skin burn-through could result in a serious injury to crew, passengers or ground personnel, should be fireproof under all conditions. Serious hazards include, but are not limited to, events such as fuel tank explosion, hazardous spread of fire to flammable fluid sources outside the fire zone, or fuselage penetration.

2.1. Pod mounted engines: The portion of the nacelle skin, which is required to be fireproof on ground, varies by installation. A design is considered acceptable when it is demonstrated that the fireproof area protects the pylon strut and other portions of the aircraft considered to be put at a serious hazard risk if burn through occurs. Factors to consider within the analysis and to use when substantiating the design are: the engine location - wing or aft mounted, the coupling distance of the nacelle to the wing, the airflow characteristics, the fluid migration scheme and the fire plume patterns. After the initial analysis, a similarity demonstration may be used when appropriate. Analyses have demonstrated that the typical area of concern ranges from 90° (±45°) to 180° (± 90°). This area may increase or decrease depending on the analysis results. For example, most wing mounted engines not closely coupled to the wing have been found acceptable with a ±45° protection while more closely coupled installations and those with other unique design features have required ±90°protection.
The symmetry of the protection may also vary. Wing mounted engines usually have symmetrical protection while aft mounted engines may have non-symmetrical protection in order to cover more of the inboard area.

2.2. Turboprops and APUs and other non-pod mounted engines: Due to the wide variations in installation configurations each installation should be evaluated to determine if a skin burn-through would cause a serious hazard such as the examples above. If so the affected area of the fire zone skin should be fireproof. Examples of common configurations, which have been found to be acceptable, are:

- Stinger mounted APUs not requiring fireproof skins if critical parts of the airplane are not exposed.
- Stinger mounted APUs requiring partial fireproof skins, such as ±45° to protect adjacent critical parts of the airplane.
- APUs mounted in fireboxes internal to the fuselage where the side of the box, which is external skin, is fireproof to protect against re-entering of a fire which burns through.

3. Other nacelle areas: - For the remaining portions of skin in areas subject to flame if a fire starts in an engine or APU fire zone, the degree of fire protection can be lower than "fireproof" due to less serious or less probable hazard of a burn-through to the airplane and / or its passengers under the critical operating conditions.

Fire resistant skins provide adequate fire protection for those areas in that they provide sufficient time to stop the airplane and evacuate it.

A lower than "fire resistant" degree of fire protection has been used by applicants in the past without adverse service experience and can be considered under the following conditions:

- nacelle skin should have the ability to withstand fire at least equivalent to 0.040" (1 mm) aluminum
- applicants must substantiate that this lower fire protection level will not lead to hazardous effects such as :
  - Reduction in evacuation capability due to proximity to escape routes or due to the visibility of the fire hindering the ability of the passengers to evacuate the airplane in a rapid and orderly manner. Visibility effects are a combination of line of sight to the fire and proximity. For example, an over wing exit may require no line of sight, while line of sight may be permissible for a forward exit due to greater distance from the nacelle. (Note: There is some hazard involving passenger evacuation even in the absence of burn-through, due to such concerns as smoke and flaming liquids exiting from openings. Burn-through of nacelle skin should not significantly increase these hazards.)
  - Reduction in fire detection capability such that the flight crew would not be aware of the fire, especially in a situation involving taxiing prior to takeoff.
  - A reduction in fire extinguishing capability which could cause or aggravate one of the potential hazards listed above

III. <u>Specific Configuration Considerations</u>

A. Multiple Skin Layers

For some specific fire zones, a fire originating in that zone will have to pass through several layers of skin or cowling before burning through the nacelle external skin. This may be the case, for example, for the core zone of some turbofan installations. In such cases, credit may be taken for multiple layers, having regard to the location of the fire source and the likely direction of propagation from that location, providing burn-through of the inner layer does not produce other hazardous effects as well as does not invalidate other certification requirements such as fire extinguishing capability. The corresponding compliance substantiation should take into account particular geometrical configuration with respect to risk of flame propagation, as well as critical systems or structures.

B. Inlet Skins

External inlet skins, which enclose fire zones, should meet the same criteria discussed. Inlet ducts should meet the requirements of 25-1103.

C. Openings

The following considerations are applicable to openings in a fire zone skin, whether the openings are of fixed size, variable or controllable size, or normally closed, such as access or inspection doors, or pressure relief doors.

- Openings should be located such that flame exiting the opening would not enter any other region in where it could cause a hazard in flight or a serious hazard per II.C on the ground, except for covered openings which meet the same criteria for ability to withstand the effects of fire as the surrounding cowl skin, and which are not expected to become open under fire conditions. Since pressure relief doors may open during some fire conditions, they should be located so that flames exiting the door will not cause a hazard. However, since the doors will remain closed during most fire conditions, or will tend to re-close following initial opening, the doors can be assumed to be closed for the purposes of fire detection and extinguishing.

- Openings should have the same ability to withstand the effects of fire as the adjacent skin with respect to becoming enlarged under fire conditions. Some enlargement, such as burning away of louvers or doublers surrounding the opening or gapping of covered openings, is acceptable providing that the hazard is not significantly increased by a reduction in fire extinguishing or detection capability, increased airflow causing increase in fire size or intensity, or increase in probability of a hazardous spread of fire to other regions.

IV. Compliance demonstration

Compliance should be substantiated per FAR/JAR 25.1207. Substantiation involving airflow patterns may include analytical methods such as Computational Fluid Dynamics, test methods such as tufting or other flow visualization methods or a combination. Fire testing should be accomplished per the guidance of AC 20-135 (ISO 2685).

Recommendation Letter

-> Effie for processing

Pratt & Whitney
400 Main Street
East Hartford, CT 06108

Pratt & Whitney
A United Technologies Company

January 17, 2000

Department of Transportation
Federal Aviation Administration
800 Independence Ave, SW
Washington, D.C. 20591

Attention: Mr. Anthony Fazio, ARM-1

Reference: ARAC Tasking, Federal Register, November 26, 1999

Dear Tony,

At the December 1999 Transport Airplane and Engine Issues Group meeting, the Powerplant Installation Harmonization Working group presented a "Fast Track" report addressing 25.903(e), Inflight Starting. This report had been prepared in accordance with the reference tasking.

The 25.903(e) report submittal to TAEIG included a number of significant opposing views from PPIHWG members that had not been resolved. After extensive discussion it was concluded that returning the report to the Working Group at this time was unlikely to result in resolution of the differences. It was then concluded that the best course of action would be to forward the attached, 25.903(e) report with the minority opinions to the FAA for further processing into NPRM and draft Advisory Circular format. Following FAA completion of this activity, it is requested that in accordance with the "Fast Track" process that the package be returned to TAEIG for review with the PPIHWG in order to provide an opportunity to reach consensus.

ANM-98-480-A
TASK # 5
Phase II
2a

Please feel free to contact me if additional information is required.

Sincerely yours,

C. R. Bolt

C. R. Bolt
Assistant Chair, TAEIG
Phone: 860-565-9348, Fax 860-557-2277, M/S 162-24
Email: boltcr@pweh.com

Attachment: Diskette
cc: Dorenda Baker – FAA-NWR*
Kristin Larson – FAA-NWR
Phil Sallee – Boeing*
Effie Upshaw – FAA - ARM
*letter only

Acknowledgement Letter

MAR 15 2000

Mr. Craig Bolt
Assistant Chair, Transport Airplanes
and Engines Issues Group
400 Main Street
East Hartford, CT 06108

Dear Mr. Bolt:

This letter acknowledges receipt of the following working group technical reports that you have submitted on behalf of the Aviation Rulemaking Advisory Committee (ARAC) on Transport Airplane and Engine Issues (TAE):

Date of Letter	**Task No.**	**Description of Recommendation**	**Working Group**
12/14/00	1, 2, 3	Fast track reports addressing §§ 25.703(a) thru (c) (takeoff warning system); 25.1333(b) (instrument systems; and 25.1423(b) (public address system)	ASHWG
12/17/00	5	Fast track reports addressing §§ 25.111(c)(4), 25.147, controllability in 1-engine inoperative condition; 25.161 (c) (2) and (4), and (e) (longitudinal trim and airplanes with 4 or more engines) 25.175(d) (static longitudinal stability; 25.177(a)(b) (static lateral-directional stability); 25.253(a)(3) (high speed characteristics); 25.1323(c) (airspeed indicating system); 25.1516 (landing gear speeds); 25.1527 (maximum operating altitude); 25.1583(c) and (f) operating limitations) 25.1585 (operating procedures); and 25.1587 (performance information)	FTHWG
12/17/00	7	Fast track report addressing § 25.903(e) (inflight engine failures)	PPIHWG

12/20/00	5	Fast track reports addressing §§ 25.1103 (auxiliary power units); 25.933(a) (thrust reverers); 25.1189 (shutoff means); 25.1141 (powerplant controls); 25.1093 (air intake/induction systems); 25.1091 (air intake system icing protection; 25.943 (thrust reverser system tests); 25.934 (negative acceleration); 25.905(d) (propeller blade debris); 25.903(d)(1) (engine case burn-through); 25.901(d) (auxiliary power unit installation; and 1.1 (general definitions)	PPIHWG
12/20/00	4	Fast track report, category 2 format--NRRM addressing § 25.302 and appendix K (interaction of systems and structures	LDHWG
12/20/00	2	Fast track report—(in NPRM/AC format) addressing §§ 25.361 and 25.362 (engine and auxiliary power unit load conditions)	LDHWG
12/20/00	1	Fast track report addressing § 25.1438 (pressurization and low pressure pneumatic systems)	MSHWG

The above listed reports will be forwarded to the Transport Airplane Directorate for review. The Federal Aviation Administration's (FAA) progress will be reported at the TAE meetings.

This letter also acknowledges receipt of your July 28, 1999, submittal which included proposed notices and advisory material addressing lightning protection. We apologize for the delay. Although the lightning protection task is not covered under the fast track proposal, the FAA recognizes that technical agreement has been reached and we will process the package accordingly. The package has been sent to Aircraft Certification for review; the working group will be kept informed of its progress through the FAA representative assigned to the group.

Lastly, at the December 8 - 9, 1999, TAE meeting, Mr. Phil Salee of the Powerplant Installation Harmonization Working Group indicated that the working group members agreed that § 25.1103 was sufficiently harmonized and that any further action was beyond the scope of task 8 assigned. We agreed with the TAE membership to close the task. This letter confirms the FAA's action to close the task to harmonize § 25.1103.

Recommendation

16 November 1999

Ref. 991116/16

To: Aviation Rulemaking Advisory Committee -
Transport Airplane and Engine Interest Group (TAEIG)

From: Aviation Rule Making Advisory Committee –
Powerplant Installation Harmonization Working Group (PPIHWG)

Subject: Harmonization of FAR/JAR 25. 903(e) Inflight Starting

Attachments:

1) Draft PPIHWG Report on 25.903(e) – Inflight Starting dated 8/16/99 and AC/ACJ 25.903(e) revision dated 8/12/99
2) Draft NPRM on Engine Inflight Restart Requirements dated September 14, 1999
3) A BETTER PLAN FOR HARMONIZATION: PPSG REVIEW OF CAT 1 AND 2 ITEMS (JAA-PPSG)
4) Airbus/Aerospatiale Comments on the "Package", Issue No. 2 of November 04, 1999.
5) Airbus Industrie letter, Subject: Latest Draft on Inflight Restart ACJ, Dated 13 September 1999 from J. Joye
6) Cessna Minority Position on Draft AC/ACJ 25.903(e) dated August 19, 1999
7) Allied Signal Engines and Systems Comments on Proposed 25.903(e) dated November 2, 1999
8) GEAE Minority Position on proposed AC 25.903(e) dated September 17, 1999
9) P&W Comments on Proposed 25.903(e) dated September 21, 1999
10) GEAE Letter Subject: 25.903(e) response dated October 19, 1999
11) Input on Proposed Harmonization Docs – 23rd PPIHWG Montreal by Gordon Cooper (RR)

In accordance with the 4 June 1999 Better Plan for Harmonization, PPIHWG submits Attachment 1 through 11 related to harmonization of FAR/JAR 25.903(e) – Inflight starting.

As background, the Aerospace Industries Association (AIA) undertook a project on the subject of inflight engine restarting requirements at the request of the Federal Aviation Administration (FAA) in 1991. The project, AIA PC-345, had meetings over several years but was unable to develop a consensus proposal or arrive at a meaningful recommendation. In 1995, the PC345 Project team abandoned their efforts and turned the activity over to the Powerplant Installation Harmonization Working Group. PPIHWG accepted the Task based on FAA encouragement citing the flight safety need, use of generic special conditions, and with the understanding that appropriate tasking was forthcoming. The work to develop a proposed rule change and advisory material to address "all engine out - inflight restarting requirements " was continued under PPIHWG as a separate AIA/AECMA project. The activity was completed, without formal tasking, by consensus agreement at the PPIHWG September 1998 Seattle meeting. The basis for consensus was that all parties thought the proposal was the best that could be developed and was "livable". As agreed, the AIA/AECMA project submitted a draft petition for rulemaking via the AIA to the FAA. Attachment 2 is the NPRM part of that AIA submission. Formal tasking was then delivered by TAEIG in December of 1998. The JAA subsequently completed their review of the AIA/AECMA proposal and the comments were dispositioned in a manner acceptable to the JAA. In the interim, the FAA denied the AIA petition for rulemaking, citing resource problems and the fact that the activity was tasked to be harmonized. A Better Plan Report with the draft AC/ACJ 25.903(e) was prepared and circulated for comments within PPIHWG. A number of unexpected minority positions were submitted at this late stage. It is noted that some but not all of the representatives who submitted minority reports were not members of PPIHWG or the AIA/AECMA Project Team at the September 1998 meeting.

After careful consideration the PPIHWG Co-Chairs consider that there is no ability to disposition the critical comments or to achieve yet another consensus position on the subject of 25.903(e) within the time frame permitted under the Better Plan for Harmonization. In part, the historical difficulty in obtaining an agreement may be related to the fact that engines certified under FAR Part 33 are not required to demonstrate an inflight engine starting capability [however, a capability is required by JAR-E 910 – Relighting in flight]. This leaves the requirement for inflight engine restarting to mitigate the hazard from an all engine out failure condition to be addressed by engine installers under Part 25.

Attachment 1 was submitted for PPIHWG member review and comment. Attachment 2 had not been changed and no further review was considered to be necessary. The PPIHWG member comments received are presented in Attachments 3 through 11. All attachments are to be dispositioned by the FAA/JAA in preparation of the proposed draft rule and Advisory material in Phase 3 and are then to be considered by PPIHWG in Phase 4.

Respectfully;

G. P. Sallee

G. P. Sallee
(Co-Chair PPIHWG)

To:- Phil Sallee - Seattle

c. D Gibbons

Re Input on Proposed Harmonisation Docs – 23rd PPIHWG Montreal

1 FAR/JAR I ----- No Comment
2 25.901(d) APU Report ----- No Comment
3 25.903(e) Combustor Burnthrough

In section 7, Engine Case Burnthrough Model, Rolls Royce believes that the default flame characteristics that should be considered should be 2000 deg C (3632 deg F). The value of 3000 deg F as a default is too low.

In section 8, based on some in service incidents, the words 'will generally fail in a very localised area' should be 'can fail under these conditions' etc. i.e. the effects need not be very localised and words which imply this should be removed.

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5 25.905 ----- No comment.
6 25.934 ----- No comment.
7 25.934 ----- No comment.
8 25.943 ----- No comment.
9 25.1091 ----- No comment.
10 25.1093 ----- No comment
11 25.1141 ----- No comment.
12 25.1187 Drainage and Ventilation Report

Within the draft AC on page 5, in section 2 the words say that the drainage system is not expected to accommodate large leaks, and a flow capacity of 1 gall /min has been acceptable in the past. This statement seems to be in conflict with AC25.1189 para 7.1.A.1) which talks about massive leaks.

On page 7, (1) Ground Test, as in other area's of this report the use of 'gallons' and 'fluid ounces' should be clarified as US or imperial. (Liters is actually spelt Litres).

13 25.1189 Flammable Fluid Shut-off Means

In the AC in section 7.2, a volume of 0.95 litres or 1 US quart, is quoted as being non-hazardous, whereas in P-NPA-E-37 definition (f) the volume as non-hazardous is 0.25 litres. The values should be consistent, in addition, if a volume of 0.25 (or 0.95) litres is non hazardous, why is an individual volume of 3.75cl the maximum in 25.1187?

Regards, Gordon Cooper

Recommendation Letter

-- Office for processing

Pratt & Whitney
400 Main Street
East Hartford, CT 06108

Pratt & Whitney
A United Technologies Company

January 17, 2000

Department of Transportation
Federal Aviation Administration
800 Independence Ave, SW
Washington, D.C. 20591

Attention: Mr. Anthony Fazio, ARM-1

Reference: ARAC Tasking, Federal Register, November 26, 1999

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ANM-98-480-A
~~TAE~~ #2a

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Sincerely yours,

C. R. Bolt

C. R. Bolt
Assistant Chair, TAEIG
Phone: 860-565-9348, Fax 860-557-2277, M/S 162-24
Email: boltcr@pweh.com

Attachment: Diskette
cc: Dorenda Baker – FAA-NWR*
Kristin Larson – FAA-NWR
Phil Sallee – Boeing*
Effie Upshaw – FAA - ARM
*letter only

Recommendation

To:- Phil Sallee - Seattle

c. D Gibbons

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Regards, Gordon Cooper

DRAFT NPRM
DATED September 14,1998

This draft Notice is revised to include the comments from the July, 1998 ARAC meeting in Seattle.

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[14 CFR Part 25]

[Docket No. ; Notice No.]

RIN: 2120-

Engine Inflight Restart Requirements

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking.

SUMMARY: This notice proposes an amendment to the airworthiness standards for transport category airplanes to establish engine inflight restart requirements following the loss of all engine power. The need for a rule change is based upon review of service experience that shows cases of all engine thrust losses (flameouts or shutdowns) have occurred for various causes and the ability to restart engines was required to provide continued safe flight and landing. Review of FAA approved inflight restart envelopes for some newly certificated airplanes shows reduced engine windmill restart capability which has significantly increased altitude loss required to affect engine restart following all engine thrust loss. This information indicates there is a need to revise the inflight engine restart requirements to provide minimum engine relight capability within the airplane operating envelope following loss of all engine thrust. If adopted, this proposal would establish requirements for inflight engine restart capability following loss of all engine power for transport category airplanes.

These proposals were developed in cooperation with U.S. and European aviation industry task groups including the Aerospace Industries Association of America (AIA) and the European Association of Aerospace Industries (AECMA). These changes are intended to benefit the public interest by establishing a minimum standard for recovery following the flameout or shutdown of all engines.

DATE: Comments must be received on or before

ADDRESS: Comments on this proposal may be mailed in triplicate to: Federal Aviation Administration, Office of the Chief Counsel, Attention: Rules Docket (AGC-10), Docket No. 800 Independence Avenue SW., Washington, D.C. 20591, or delivered in triplicate to: Room 915G, 800 Independence Avenue SW., Washington, D.C. 20591. Comments delivered must be marked: Docket No. Comments may be inspected in Room 915G weekdays, except Federal holidays, between 8:30 a.m. and 5:00 p.m. In addition, the FAA is maintaining an information docket of comments in the Office of the Assistant Chief Counsel (ANM-7), FAA, Northwest Mountain Region, 1601 Lind Avenue S.W., Renton, Washington 98055-4056. Comments in the information docket may be inspected in the Office of the Assistant Chief Counsel weekdays, except Federal holidays, between 7:30 a.m. and 4:00 p.m.

FOR FURTHER INFORMATION CONTACT: Michael J. Kaszycki, Airframe and Propulsion Branch (ANM-112), Transport Airplane Directorate, AirCraft Certification Service, FAA, Northwest Mountain Region, 1601 Lind Avenue S.W., Renton, Washington 98055-4056; telephone (425) 227-2137.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to participate in this proposed rulemaking by submitting such written data, views, or arguments as they may desire. Comments relating to the environmental, energy, or economic impact that might result from adopting the proposals contained in this notice are invited. Substantive comments should be accompanied by cost estimates.

Commenters should identify the regulatory docket or notice number and submit comments, in triplicate, to the Rules Docket address specified above. All comments received on or before the closing date for comments will be considered by the Administrator before taking action on this proposed rulemaking. The proposals contained in this notice may be changed in light of comments received. All comments will be available in the Rules Docket, both before and after the closing date for comments, for examination by interested persons. A report summarizing each substantive public contact with FAA personnel concerning this rulemaking will be filed in the docket. Commenters wishing the FAA to acknowledge receipt of their comments must submit with those comments a self-addressed, stamped postcard on which the following statement is made: "Comments to Docket No. ." The postcard will be date/time stamped and returned to the commenter.

Availability of NPRM

Any person may obtain a copy of this Notice of Proposed Rulemaking (NPRM) by submitting a request to the Federal Aviation Administration, Office of Public Affairs, Attention: Public Inquiry Center, APA-430, 800 Independence Avenue SW., Washington, D.C. 20591, or by calling (202) 267-3484. Communications must identify the notice number of this NPRM. Persons interested in being placed on a mailing list for future rulemaking documents should also request a copy of Advisory Circular No. 11-2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedures.

Discussion of the Proposals:

Following several all engine out incidents, the FAA held a public meeting in 1986 to discuss all engine out restart capabilities. Subsequently the FAA issued special conditions that established minimum restart requirements that were intended to maintain the level of safety on new type designs to that of earlier technology airplanes. The Joint Aviation Authorities (JAA) have already clearly defined the European engine restart requirements in ACJ of JAR-25. The JAA has published specific guidance regarding the minimum restart requirements within the Acceptable Means of Compliance and Interpretations-ACJ to the Joint Airworthiness

Requirements (JAR). The guidance includes; flight crew delay times for initiation of a start, guidelines for test altitudes, configurations, and airspeeds associated with starter assist and windmill restart of engines. Differences between the FAA special conditions and the JAA compliance criteria for showing compliance to 25.903(e) have resulted in two different standards for certification of transport airplanes. Thus, the objective of this proposed amendment is to establish a minimum standard for recovery following the flameout or shutdown of all engines.

Regulatory History

The inflight engine restart requirements for turbine powered airplanes are identified in §§ 25.903, 25.1351 and 25.1585 of the Federal Aviation Regulations (FAR). Sections 25.903 and 25.1585 requirements were developed from the engine inflight restart requirements of the earlier Civil Air Regulations (CAR) Part 4b. Paragraph 4b.401(c) required the ability for individually stopping and restarting the rotation of any engine during flight. This intention was further incorporated into Part 25, specifically § 25.903(e), which requires 1) the ability to restart any engine during flight must be provided, 2) an altitude and airspeed envelope must be established for inflight engine restarting, and each engine must have a restart capability within that envelope and, 3) if the minimum windmilling speed of the engines following the inflight shutdown of all engines, is insufficient to provide the necessary electrical power for engine ignition, a power source independent of the engine driven electrical power generating system must be provided to permit inflight engine ignition for restarting. In addition, FAR 25.1351(d) requires demonstration that the airplane can be operated for 5 minutes following the loss of all normal electrical power (excluding the battery) with the critical type fuel (from the standpoint of flame out and restart capability) and with the airplane initially at the maximum certificated altitude. For airplanes equipped with Alternating Current (AC) powered fuel pumps, this requirement has resulted in demonstration of the capability to windmill relight the engine while on suction feed with battery power for ignition with relight usually occurring at altitudes between 16,000 to 25,000 feet.

In addition, as stated earlier in CAR 4b.742(d), the recommended procedures to be followed in restarting turbine engines in flight are to be described, including the effects of altitude. This intention was also incorporated into Part 25, specifically § 25.1585(a), which states that information and instructions must be furnished, together with recommended procedures for restarting turbine engines during flight (including the effects of altitude).

Background

Since the introduction of turbojet and turbofan engines into commercial service newer technology high bypass ratio engines have been developed which improve fuel efficiency, reduce emissions, and improve engine tolerance to severe inclement weather conditions. However, some engines incorporating these improvements have shown a tendency to require increased airspeed to provide sufficient windmilling rotational energy to the engine core for restarting. When the existing Part 25 requirement was developed the engine windmill relight capability covered nearly the entire airplane airspeed and altitude operational envelope, including low altitude low speed conditions. Many newer technology engines that incorporate improved fuel efficiency, lower emissions, and improved tolerance to inclement weather conditions have demonstrated relight envelopes which in many cases are limited to higher airspeed conditions. In addition, other engine installations have been developed which utilize free turbine type engines that may require either an electrical or pneumatic power source for inflight restart.

These characteristics have resulted in a gradual reduction in the size of engine inflight windmill relight envelopes on some newer technology engines. Today many newer technology airplanes require starter "assists" from a pneumatic source such as another operable engine or an inflight operable Auxiliary Power Unit (APU) over a large portion of the airplane operating envelope.

The task group, consisting of AIA, AECMA, and FAA members, has assembled a list of over thirty all engine out events that have occurred between 1959 and 1997. Review of reported incidents of all-engine flameout or shutdown events on transport category airplanes indicates that a minimum engine restart capability is needed to sustain the current level of safety. The task group has recommended establishing a minimum engine restart capability for the all engine out case.

The data indicates that multi-engine flameouts or shutdowns have generally resulted from a common cause, such as fuel system mismanagement, crew action that inadvertently shutoff the fuel supply to the engines, exposure to common environmental conditions, or engine deterioration occurring on all engines of the same type.

Discussion

The current regulations were developed based on the understanding that turbine engines inherently had an adequate inflight windmill relight capability therefore, only an electrical power source for engine ignition was required to permit inflight engine restarting following an all engine flameout or shutdown. The reduction in restart capability that has occurred as new technology engines were developed was not foreseen when the restart regulations were promulgated. Several recently certified airplane types have a significantly reduced inflight windmill restart envelope, and assured recovery from an all-engine flameout or shutdown requires one of the following: (1) quick response from the flightcrew to restart the engines before the engine rotor speed falls below minimum values, (2) sufficient altitude to allow the flight crew time to achieve a high airspeed within the engine windmill restart envelope, or (3) an appropriate bleed air source such as an inflight operable APU to allow starter assisted engine restart.

The current regulations do not adequately assure successful inflight engine relight capability under certain circumstances, particularly during flight at low airspeeds and altitudes, following a multi-engine inflight flameout or shutdown. The FAA has concluded that a minimum level of restart capability is necessary to maintain an adequate level of safety for transport category airplanes.

The FAA has issued Airworthiness Directives requiring relocation of engine shutoff switches in one airplane type, increased inflight engine idle thrust levels during descent and subsequent engine modifications to another airplane type to reduce the likelihood of all engine out incidents occurring as described earlier. In addition, aircraft manufacturers have developed new flight crew procedures to achieve "rapid" relight of the engines following failure so that relight can be attained before the engine rotor speed falls below minimum values during the takeoff portion of the flight. The FAA is continually monitoring service difficulty reports to determine if AD action may be necessary on other transport airplanes that may exhibit unsatisfactory engine relight capability. Newer technology higher bypass ratio engines currently under development are expected to have inflight restart envelopes that require starter assisted relight capability over a larger portion of the present baseline envelope. The FAA proposes to revise the regulatory standard to provide an adequate level of safety.

Regulatory Options

Within the regulatory revision context, several options were considered by the FAA, including: (1) requiring a windmill start capability throughout an airplane's entire flight envelope thus alleviating the all-engine flameout/relight concern, (2) requiring additional equipment necessary to provide expanded starter assistance capability, such as start cartridges, (3) requiring certification of an inflight operable APU as an acceptable air source for starter assistance and thereby making APU's required airplane equipment and requiring either full time operation during certain portions of flight or demonstrated ability to start the APU when needed.

The proposed amendment does not specifically require or prevent any or all of the options presented above. The airplane manufacturer may investigate these options and any others for a suitable method to provide the required engine inflight restart capability.

Regulatory Intent

The FAA considers that a reasonable restart envelope must assure restart of the engines prior to a loss in altitude that would preclude continued safe flight and landing.

Several methods are available to an applicant that would permit a more responsive and reliable restart capability, such as providing an inflight operable APU within the restart envelope for engine starter assistance or providing engine modifications. Other methods may also be available to the applicant to ensure a reliable restart capability. Therefore the FAA does not require, within the proposed regulatory amendment, any specific method that would satisfy the minimum inflight restart requirement.

Future Advisory Circular

Many variables presently exist that influence the capability of turbojet engines to perform an. acceptable inflight restart, including: engine bypass ratio, altitude and airspeed/mach number, engine stability, outside air temperature, the presence of precipitation, idle rotor speed, shut-down duration (cold soak), engine time since overhaul, installed configuration (accessory loads); and engine fuel control/surge bleed valve schedules. These and other variables may equally affect the capability of a turbopropeller engine to restart during flight.

Although it is necessary for all engine installations to be flight tested to establish and demonstrate an engine restart envelope during flight, the FAA has not required each engine type to demonstrate restart capability under the influence of all variables affecting relight capability. Some technical experience and analysis may be necessary to determine those variables with the greatest effect on the engine restart capability and those that would reasonably need to be considered to assure continued safe flight and landing.

The group has also assisted the FAA in developing an advisory circular to identify and clarify acceptable means to demonstrate compliance with the regulation proposed within this 'notice. This AC will provide guidelines to be used by the airframe manufacturer for conducting a safety analysis to establish both the minimum required restart capability and assist in certification flight test planning.

Regulatory Evaluation

Regulatory Flexibility Determination

Under the criteria of the Regulatory Flexibility Act of 1980 (RFA), the FAA has determined that the proposed rule would not have a substantial economic impact on a substantial number of small entities.

Since the act applies to U.S. entities, only U.S. manufacturers of transport category airplanes would be affected. In the United States, the Boeing Company is the only manufacturer that specializes in commercial transport category airplanes. In addition, there are a number of others that specialize in the manufacture of other transport category airplanes, such as those designed for executive transportation. These include Cessna Aircraft Corporation, Bombardier, Raytheon, and Gulfstream American Corporation.

The FAA size threshold for a determination of a small entity for U.S. airplane manufacturers is 75 employees; any U.S. airplane manufacturer with more than 75 employees is considered not to be a small entity. Because none of the transport category airplane manufacturers is a small entity, there would be no impact on any small entity as the result of the implementation of this proposal.

International Trade Impact Assessment.

The proposed rule is not expected to have an adverse impact either on the trade opportunities of U.S. manufacturers of transport category airplanes doing business abroad or on foreign airplane manufacturers doing business in the United States. Since the certification rules are applicable to both foreign and domestic manufacturers selling airplanes in the United States, there would be no competitive trade advantage to either.

Federalism Implications

The regulation proposed herein would not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this proposal would not have sufficient implications to warrant the preparation of a Federalism Assessment.

CONCLUSION: Because the proposed provisions are not expected to result in a substantial economic cost; the FAA has determined that this proposed regulation is not considered to be major under Executive Order 12291. Additionally, as this document involves an issue that has not prompted a great deal of public concern, it is not considered significant under Department of Transportation Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). Since there are no small entities affected by this rulemaking, it is certified under the criteria of the Regulatory Flexibility Act that this proposed rule, if promulgated, would not have a significant economic impact, positive or negative, on a substantial number of small entities. A copy of the initial regulatory evaluation prepared for this project may be examined in the public docket or obtained from the person identified under the caption, "FOR FURTHER INFORMATION CONTACT."

List of Subjects in 14 CFR Part 25: Aircraft Aviation safety, Engines, Restart.

The Proposed Amendment

Accordingly, the Federal Aviation Administration (FAA) proposes to amend Part 25 of the Federal Aviation Regulations (FAR), 14 CFR Part 25, as follows:

Part 25 - AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for Part 25 continues to read as follows:

Authority: 49 U.S.C. 1344, 1354(a)7 1355, 14217 1423,1424,1425,1428, 1429, 1430; 49 U.S.C. 106(g) (Revised Pub. L. 97-449; January 12, 1983); and 49 CFR 1.47(a).

2. By amending § 25.903 by adding a new paragraph (e)(4) that read as follows:

§ 25.903 Engines.

* * *

EXISTING WORDING SHOWN FOR COMPLETENESS

(e) ***Restart Capability.***

(1) Means to restart any engine in flight must be provided.

(2) An altitude and airspeed envelope must be established for in-flight engine restarting, and each engine must have a restart capability within that envelope.

(3) For turbine engine powered airplanes, if the minimum windmilling speed of the engines, following the in-flight shutdown of all engines, is insufficient to provide the necessary electrical power source independent of the engine-driven electrical power generating system must be provided to permit in-flight engine ignition for restarting.

(PROPOSED AMENDMENT TO TEXT)

(4) For turbine engine powered airplanes it must be shown by test and analysis that a means to restart those engines needed for continued safe flight and landing of the airplane is provided following the flame out or shutdown of all engines.

Pratt & Whitney
Main Street
East Hartford, CT 06108

Pratt & Whitney

A United Technologies Company

To: Mr. G.P. Sallee
J.C. Tchavdorov

Date: September 21, 1999

Subject: P&W Comments on Proposed §25.903(e)

While Pratt & Whitney is sympathetic with the need for an all-engine out **inflight restart** requirement, Pratt & Whitney believes that the materials presented for the revised §25.903(e) are inadequate and should not be submitted as a PPHIWG endorsed position to the Transport Aircraft & Engines Issues Group. We also submit that this proposal is not appropriate for the fast-track process and should be tasked as a full rule-making project.

Rationale for this conclusion include:

1. The submitted materials rely on material developed by the AIA/AECMA Inflight Restart committee (PC345). This effort was prematurely terminated and its report submitted as a statement of status before there was technical agreement amongst the membership. The minority opinions or negative comments received on this rule making proposal are evidence of the lack of technical agreement.
2. A copy of the NPRM that is proposed to be submitted to the TAEIG has not been distributed to the PPIHWG membership for review as a component of this package.
3. The proposed new rule language (assuming the version from AIA/AECMA report is current), "[f]or turbine engine powered airplanes, it must be shown by test and analysis that a means to restart those engines needed for continued safe flight and landing of the airplane is provided following the flame out or shutdown of all engines", is inappropriately vague and sets forth a requirement that may be impossible to meet for any imagined circumstance. This rule language does not meet the intent put forth in the PPHIWG Report on 25.903(e) - Inflight Restart, "to amend the regulation to clearly address the all engine out failure condition and provide a minimum inflight re-starting capability to be achieved". The rule should clearly define the minimum safety standard by clearly specifying the condition(s) that must be addressed.
4. The draft Advisory Circular included in the PPHIWG contains a significant amount of regulatory material. This is not reflective of "a means, but not the only means" of compliance. Examples of this language include (but are not limited to):
   - Section 7: "Four conditions are to be addressed:"
   - Section 7 "Each zone must be identified in the Airplane Flight Manual. Sufficient tests must be carried out in each zone to validate it reliably."

- Sections 8.3 & 8.4: "The same *criteria* as in §8.2 should be used for times to relight & spool-up." (italics added for emphasis)
- Section 8.5: "... for compliance with any of the section 7 restart conditions..."
- Section 8.5: "- a minimum of 95% APU start reliability must be demonstrated by test..."
- Section 8.5: "- if an APU assisted engine start is used for complying with the Low altitude conditions I or IV..."

In addition to the above concerns, P&W offers the following technical comments on the proposed Advisory Circular. These items also indicate a general lack of maturity in the Advisory Circular.

1. Section 4.3: The indication "low altitude possible", included in the citation of volcanic ash experience should be deleted, as the discussion in this section should be restricted to a pure statement of history.
2. Section 7: The statement "...the applicant will be expected to show by test or analysis supported by tests..." is inconsistent with the proposed rule language, "...it must be shown by test and analysis...". The rule language should be modified to allow either test or validated analysis.
3. Section 6.1: The following guidance is provided: "Several manufacturers have implemented features which are intended to enhance safety by reducing the likelihood of engine damage during start or eliminating all engine flame-out events for specific causes. These systems may improve safety but should not be considered as eliminating the need for a safety evaluation of all engine power loss occurrences". However, this is contradicted by guidance under Section 7, item 4) which indicates that credit may be given for systems that minimize the likelihood of all engine out conditions. The text in section 6.1 should be modified to be consistent with Section 7.
4. Section 7, item 4): The text indicates that credit may be given for aircraft safety devices that minimize the likelihood of the all engine out condition ("aircraft design features which minimize the potential for inadvertent shutoff", automatic relight, and automatic sub-idle stall recovery systems). However, there is no additional guidance for the applicant on this subject, nor is this credit reflected in the "Acceptable Means of Compliance" listing in the table summarizing the compliance guidelines. Finally, there is no indication that the applicant can obtain similar credit for the presence of these safety systems for the other proposed compliance conditions. The summary table should be modified and credit for such systems should be extended to the other proposed conditions.
5. Section 7, item 4): No rationale is given for using 1.45 V_{STALL} (clean configuration) as the initial speed for the proposed condition. The typical flight speed for approach at 10,000 ft should be used as the initial speed.
6. Section 7: Condition IV in the summary table calls for a 250 KT maximum initial speed for the demonstration based on this being the maximum permitted airspeed below 10,000 ft altitude, However, there is ongoing activity to alter this restriction and this should be reflected in this proposed condition if the condition is retained.

7. Section 7: Condition IV in the summary table calls for a 250 KT maximum initial speed for the demonstration based on this being the maximum permitted airspeed below 10,000 ft altitude, However, there is ongoing activity to alter this restriction and this should be reflected in this proposed condition if the condition is retained.
8. Sections 7 & 8: The structure of the demonstrations proposed in the two sections is confusing. The interaction between the two sections is not always clear. For example, what is the relationship between the proposed high power demonstration under section 8.6(b) and that under section 7 items 1) &/or 2)? Restructuring of sections 7 & 8 of the Advisory Circular is required to clarify their intent and the associated demonstrations. Reference to the section of §25.903(e) to which compliance is being demonstrated should be added.
9. Section 8.2: Positive indication of normal start progression should be sufficient to demonstrate acceptable windmill starting capability. The time requirements should be removed from this section.
10. Section 8.3: Text proposes rapid relight demonstrations should be performed with "engine initially stabilized at idle". This is inconsistent with the take off case (section 7, item 1), where rapid relight is an acceptable means of compliance.
11. Section 8.6(b): The text "the engine should relight and reaccelerate to its original power without any crew actions other than selecting ignition and fuel" imposes an additional restriction on acceptable rapid relight procedures that is not present in other discussions of rapid relight acceptability. This text should be deleted.

Pratt & Whitney remains committed to the development of a regulatory requirement for all-engine out inflight restart. However, due to the concerns outlined above, we can not support the current proposal at this time. Instead, we recommend that this project be removed from the fast-track process and tasked as a full, cooperative government-

Michael Romanowski
Manager
Flight Safety, Certification, & Airworthiness
Pratt & Whitney

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GE Aircraft Engines

Sarah M. Knife
GE Aircraft Engines
One Neumann Way, Cincinnati, OH 45215-1988

Mail Drop: J60
Dial Comm: 8-332-3032
Phone: 513-243-3032
E-Mail: sarah.knife@ae.ge.com

October 19, 1999

Subject: 25.903e Response

To: GP Sallee/Boeing Commercial Airplane Group
JC Tchavdorov/Airbus Industrie
Mike McRae/Federal Aviation Administration
Robin Boning/Civil Aviation Authority

Ref.: 25.903e Response

It has become apparent that there is considerable technical disagreement over the contents of draft rule and AC 25.903e. (Ref. 1, 2, 3) In view of this widespread technical disagreement and the magnitude of the proposed departure from current industry practice, GE supports Pratt & Whitney's request that the draft rule and AC not be presented to TAEIG, and that this rule should be removed from the fast-track process and tasked as a full rule-making project.

In the interim, GE proposes that the Generic Special Condition (Ref. 4) continue to form the basis for demonstration of compliance with the intent of 25.903e.

References:

1 GE Minority Position on Proposed AC 25.903(e), September 17, 1999, S Knife to GP Sallee and JC Tchavdorov
2 P&W Comments on Proposed 25.903(e), September 21, 1999, M Romanowski to GP Sallee and JC Tchavdorov
3 Cessna Minority Position on Draft AC/ACJ 25.903(e), August 19, 1999, B Miles and R Barnes to GP Sallee and JC Tchavdorov
4 Generic Special Condition

Original signed by Bev Kersh for

Dr. Sarah M. Knife
Senior Staff Engineer - Industry & Regulatory Affairs
Flight Safety Office, GE Aircraft Engines

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GE Aircraft Engines

Sarah M. Knife
GE Aircraft Engines
One Neumann Way, Cincinnati, OH 45215-1988

Mail Drop: J60
Dial Comm: 8-332-3032
Phone: 513-243-3032
E-Mail: sarah.knife@ae.ge.com

Subject: Minority Position on Proposed AC 25.903 e)

Date: September 17, 1999

To: GP Sallee Co-chair, PPIHWG
JC Tchavdorov Co-chair, PPIHWG

This minority position documents areas of substantive disagreement which were raised within the working group, and which were not dispositioned at the time.

A. ALTERNATE MEANS OF COMPLIANCE

This advisory material is introduced "to maintain the current level of safety" (section 4.3) with respect to recovery from an all-engine power loss event. Improving the level of safety may be achieved by reducing the likelihood of the all-engine power loss taking place, or by improving the likelihood of aircraft recovery in the event of an all-engine power loss. It can be seen from Chart 1 that the incidence of all-engine power loss is apparently decreasing. It can also be seen that the incidence of such events in high bypass ratio propulsion systems is trending downward and is now very low compared to the overall fleet history. The improvement noted in Chart 1 may be attributed to the considerable efforts made by the regulatory authorities and industry over the last 10 years, to control the incidence of all-engine power losses, by changes to the engine and aircraft requirements and design to render the engine more robust to inclement weather and FOD. It would therefore appear from service experience that reducing the likelihood of the initial all-engine out event is an effective way to maintain overall aircraft safety.

It should be noted that some of these changes have rendered windmill start more difficult, so that it may take longer or only be possible in a smaller flight envelope. However, none of the all-engine power loss events have been unrecoverable due to a small windmill start envelope, or to slow spool-up times from windmill start.

It is suggested that the intent of the rule would be better met if at least partial compliance could be demonstrated by design provisions minimizing the likelihood of the initial all-engine power loss. It is therefore proposed that wording be added as follows:

7 - COMPLIANCE GUIDANCE

This section is intended to define overall restart performance that includes the use of power assisted and windmill restart capabilities and to describe acceptable compliance guidelines.

The effects of the loss of engine power from one, multiple and all engines must be considered. However, the loss of all engines generally determines the most stringent requirements in terms of restart capability, and the intent of the regulation will be satisfied by addressing this critical case.

In order to confirm that engine restarting can be achieved, in circumstances where all engines run down or are shut down, the applicant will be expected to show by test or analysis supported by tests that sufficient power/thrust can be restored to enable the airplane to achieve level flight without excessive loss of altitude. **For propulsion systems where design provisions have been made to address the majority of known causes of all-engine power losses at a given flight condition, the risk of an unrecoverable all-engine power loss will be considered to be greatly reduced, and therefore there is no need to demonstrate compliance with the altitude loss requirement for that flight condition .**

Four conditions are to be addressed :

1. Shut down from take off/climb power with pilot recognition time delay based on analysis of indications (inherent or dedicated indicators) to the flight crews. (Pilot recognition time has typically ranged from 5 to 15 seconds based on service data.) **Service events at this flight condition have resulted primarily from crew inadvertently shutting down all engines .**

Acceptable means of compliance include rapid relight procedures or starter assistance from an external power source. The altitude loss between initiating the restart and achieving level flight should not exceed 2500 ft.

2. An engine should be able to be restarted at a minimum altitude of 15,000 ft from a shut down at typical descent speed at 20,000 ft or above. **Service events at this flight condition have resulted primarily from engine icing and fuel system malfunction.**

3. The engine should be able to be restarted with an altitude loss not exceeding 5000 ft from a power loss occurring between 10,000 and 20,000 feet. **Service events at this flight condition have resulted primarily from inclement weather and engine icing, and have only occurred for descent power.**

The aircraft speed at the time of power loss should be representative of the normal flight profile (climb or descent) in this altitude range for the flight phase considered.

4. Flame out or shut down from descent power below 10,000 ft with a delay in crew action based on indications (inherent or dedicated indicators) to the flight crew of all engine power loss. **Service events at this flight condition have resulted primarily from inclement weather (rain/hail ingestion).**

A 30 second crew recognition time should be used if no dedicated indication is provided. Crew Recognition Time may be shortened based upon dedicated indications that engines have flamed out or rolled back to sub-idle, as well as aircraft design features which minimize the potential for inadvertent shutoff. Other factors which may be considered in the crew recognition time evaluation include automatic relight and automatic sub-idle stall recovery systems.

The initial airplane speed that should be used for the all-engine out restart evaluation is 1.45 Vstall (clean configuration) of the maximum landing weight of the aircraft. Acceptable means of compliance include rapid relight, starter assistance from an external source and stabilized windmill start. The airplane should not lose more than 5000 feet altitude between initiating restart procedures and achieving level flight. In addition, the maximum aircraft speed to achieve the restart should not exceed 250 kts.

B. BASIS FOR AC IN SERVICE EXPERIENCE

Section 4.2 states "The service experience supports the position that suitable engine restart capability must be available following the loss of all engine power to avoid an unsafe condition." A database of all events of complete engine power loss occurring in the commercial transport fleet[1] was compiled by the working group. Although detailed information on airspeeds and altitudes was not available for every event, the flight phase was available for 41 of the 50 events, giving a general indication of the flight condition. (Chart 2 shows the events by flight phase, with more detailed information added where it was available.) The data collected gives a statistically valid sample of all-engine power loss events, and can therefore be used as the basis for the conditions to be flown.

The flight conditions specified in the AC do not reflect the flight conditions at which the majority of all-engine power losses have historically occurred, according to this database. Specifically, condition 4 (low power, below 10,000 ft, 1.45 Vstall) reflects a more severe condition than has been documented for an all-engine power loss in the commercial transport fleet. It is proposed that the requirement of section 7, condition 4, for an initial airspeed of 1.45 Vstall be changed to permit a higher initial airspeed such as 250 kts.

C. CAPABILITY OF EXISTING FLEET

Since this advisory material is introduced "to maintain the current level of safety" (section 4.3), the conditions to be demonstrated should be within the capability of the majority (50%) of the existing fleet. It is not possible to establish from existing data whether the majority of the existing fleet could meet section 7, condition 1 (high power fuel cut and recovery within 2500 ft), but the limited information available suggests that most of the fleet could not demonstrate this condition. The alternate means of compliance proposed above (A) may provide some relief. It is proposed that the wording of section 7, condition 1 be changed as follows:

> Acceptable means of compliance include rapid relight procedures or starter assistance from an external power source. ~~The altitude loss between initiating the restart and achieving level flight should not exceed 2500 ft~~.

Chart 3 shows the minimum windmill start airspeed as a function of aircraft certification date. Half of the engine/airframe combinations currently in service are capable of windmill start, S/L, at 250 knots. Therefore a reasonable criterion for maintaining the current safety standard would be 250 knots rather than 1.45 Vstall. The following wording change is proposed to Section 7, condition 4:

> The initial airplane speed that should be used for the all-engine out restart evaluation is **250 kts**. Acceptable means of compliance include rapid relight, starter assistance from an external source and stabilized windmill start. The airplane should not lose more than 5000 feet altitude between initiating restart procedures and achieving level flight.

Sarah M. Knife Ph.D.

[1] Excluding military action and events where at least one engine was always running, although all engines were sequentially shut down in the flight, and excluding events where engine damage during the power loss prevented restart.

Senior Staff Engineer - Industry & Regulatory Affairs
GEAE Flight Safety Office

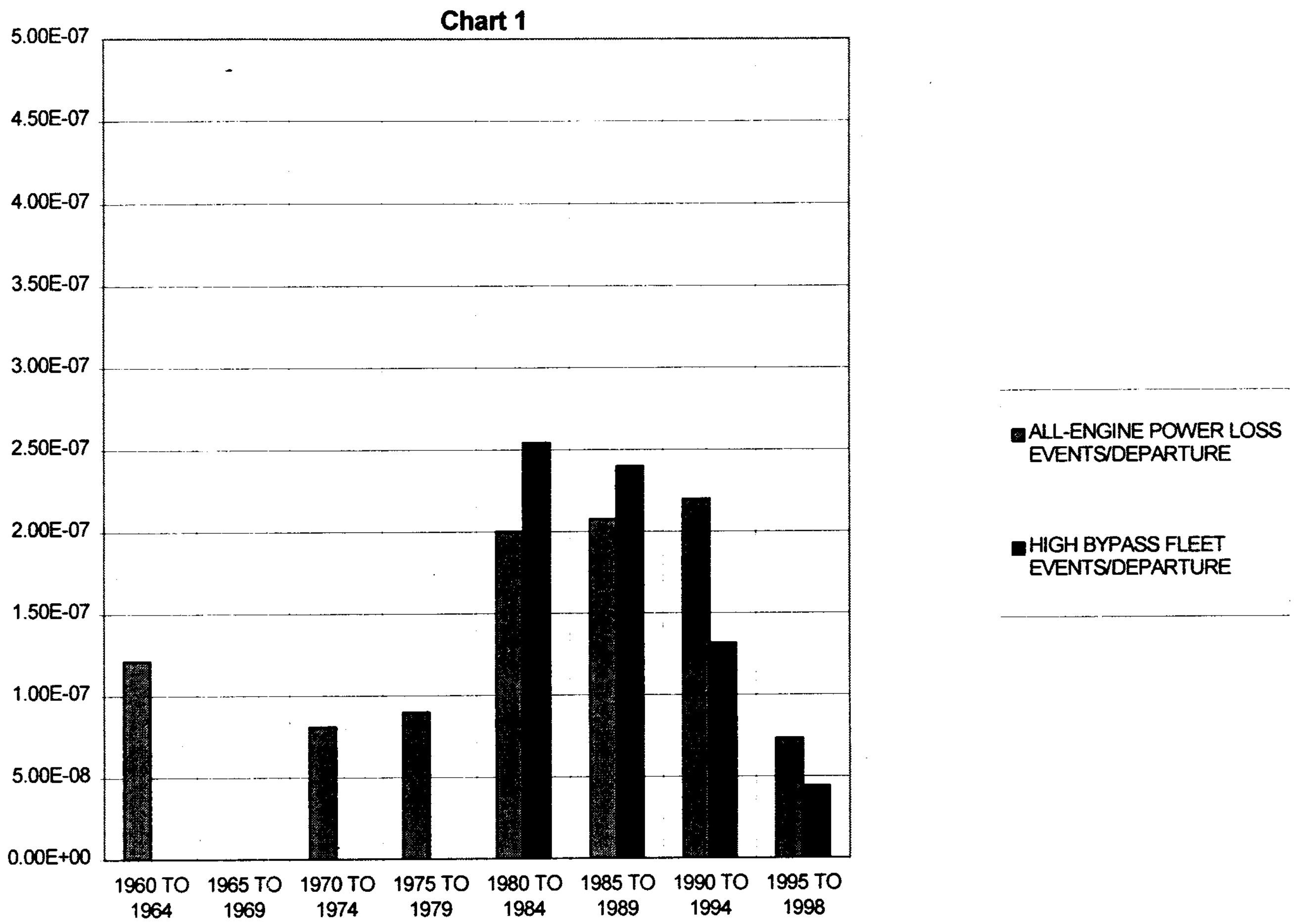
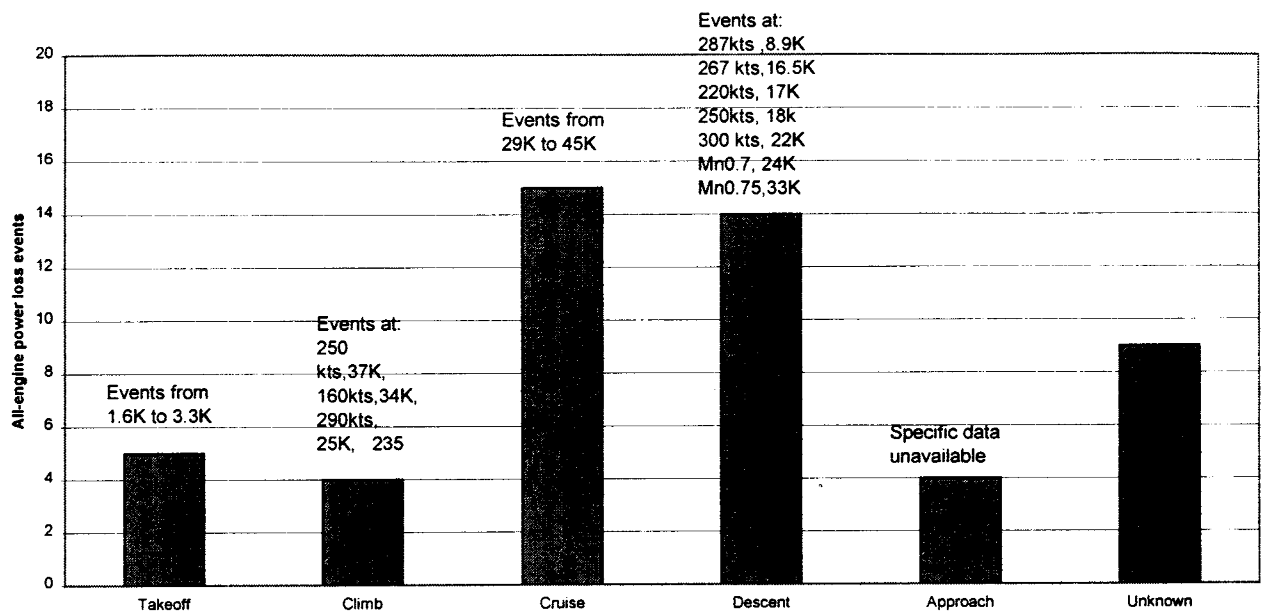


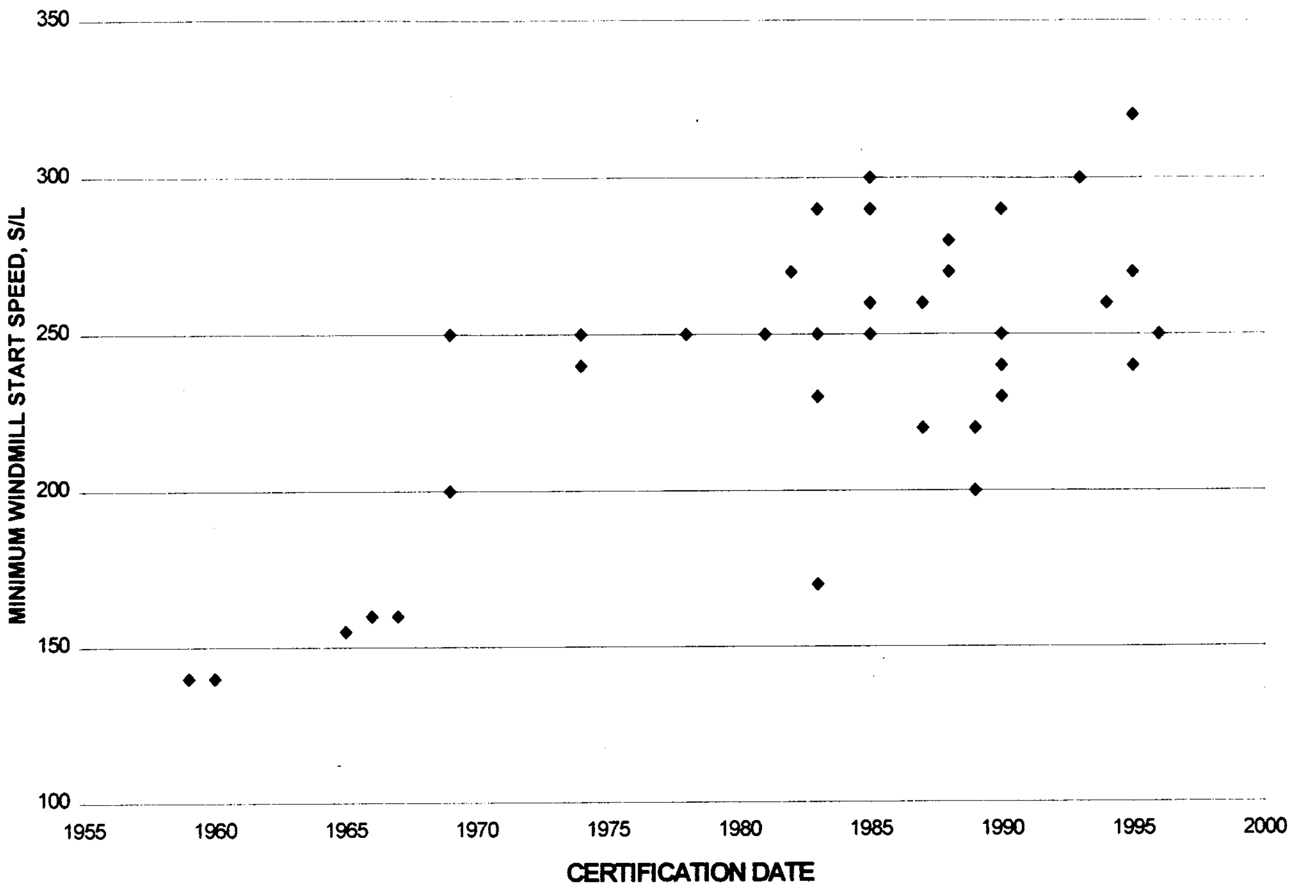
Chart 1
5.00E-07
4.50E-07
4.00E-07
3.50E-07
3.00E-07
2.50E-07
2.00E-07
1.50E-07
1.00E-07
5.00E-08
0.00E+00
1960 TO 1964
1965 TO 1969
1970 TO 1974
1975 TO 1979
1980 TO 1984
1985 TO 1989
1990 TO 1994
1995 TO 1998
ALL-ENGINE POWER LOSS EVENTS/DEPARTURE
HIGH BYPASS FLEET EVENTS/DEPARTURE

CHART 2
Commercial Transport Fleet All-Engine Power Loss Events, by Flight Phase
1960-1996



Majority of events occur at high/intermediate altitudes.
Low altitude/low airspeed/low power scenario (condition 4) represents no events/ a very small proportion of events

Chart 3
Certified Windmill Start Envelopes



AlliedSignal
AEROSPACE

AlliedSignal Inc.
AlliedSignal Engines
P.O. Box 52181
Phoenix, AZ 85072-2181
602 231 1000

November 2, 1999

Refer to: E:WCM:1215:110299

Mr. G.P. Sallee
Boeing
9725 East Marginal Way
Seattle, WA 98108

Mr. J.C. Tchavdorov
Airbus Industrie
1 Rond Point Maurice Bellonte
31707 Blagnac Cedex, France

Subject: **AlliedSignal Engines & Systems Comments on Proposed §25.903(e)**

Dear Sirs:

While AlliedSignal Engines & Systems (E&S) is sympathetic with the need for an all engines out in-flight restart requirement, E&S believes that the materials presented for the revised §25.903(e) are inadequate and should not be submitted as a PPIHWG endorsed position to the Transport Aircraft & Engines Issues Group. We also submit that this proposal is not appropriate for the fast-track process and should be tasked as a full rule-making project.

Rationale for this conclusion include:

1. The submitted materials rely on material developed by the AIA/AECMA Inflight Restart Committee (PC345). This effort was prematurely terminated and its report submitted as a statement of status before there was technical agreement amongst the membership. The minority opinions or negative comments received on this rulemaking proposal are evidence of the lack of technical agreement.

2. There seems to be confusion among the members with regard to the status of the NPRM.

3. The proposed new rule language (assuming the version from AIA/AECMA report is current), **"[f]or turbine engine powered airplanes, it must be shown by test and analysis that a means to restart those engines needed for continued safe flight and landing of the airplane is provided following the flame out or shutdown of all engines,"** is inappropriately vague. The rule does not define the conditions that resulted in the "flame out or shutdown of all engines." One or more of the engines may be damaged or not re-startable. There is no definition of the environmental conditions or minimum altitude at which the all engines shutdown condition might have to be recovered from. There is no exclusion for fuel exhaustion. The rule should clearly define the minimum safety standard by clearly specifying the condition(s) that must be addressed.

4. The draft Advisory Circular distributed to the PPIHWG contains a significant amount of regulatory material. Examples of this language include (but are not limited to):

   - Section 7: "Four conditions are to be addressed."
   - Section 7: "Each zone must be identified in the Airplane Flight Manual. Sufficient tests must be carried out in each zone to validate it reliably."

- Sections 8.3 and 8.4" "The same *criteria* as in §8.2 should be used for times to relight and spool-up." (Italics added for emphasis.)
- Section 8.5: "...for compliance with any of the section 7 restart conditions..."
- Section 8.5: "- a minimum of 95% APU start reliability must be demonstrated by test..."
- Section 8.5: "- if an APU assisted engine start is used for complying with the low altitude conditions I or IV...:

In addition to the above concerns, E&S offers the following technical comments on the proposed Advisory Circular.

1. Section 7: The statement "...the applicant will be expected to show by test or analysis supported by tests..." is inconsistent with the proposed rule language, "...it must be shown by test and analysis..." The rule language should be modified to allow either test or validated analysis.

2. Section 7, item 4: The text indicates that credit may be given for aircraft safety devices that minimize the likelihood of the all engines out condition ("aircraft design features which minimize the potential for inadvertent shutoff", automatic relight, and automatic sub-idle stall recovery systems). However, there is neither additional guidance for the applicant on this subject, nor is this credit reflected in the "Acceptable Means of Compliance" listing in the table summarizing the compliance guidelines. Finally, there is no indication that the applicant can obtain similar credit for the presence of these safety systems for the other proposed compliance conditions. The summary table should be modified and credit for such systems should be extended to the other proposed conditions. Furthermore, there has been no substantive regulatory action taken to require that cockpit design preclude known historical causes of flight crew inadvertently shutting down last operating engine through the "normal" engine shutdown means. More emphasis should be directed to preventing the "all engines out" condition, not putting the primary focus on correcting this condition after it has happened.

3. Section 7, Item 4: No rationale is given for using 1.45 V_{stall} (clean configuration) as the initial speed for the proposed condition. The typical flight speed for approach at 10,000 ft should be used as the initial speed. STOL aircraft with low V_{stall} (clean configuration) would be at a regulatory disadvantage. This speed should be increased to at least 250 KT.

4. Section 7: Condition IV in the summary table calls for a 250 KT maximum initial speed for the demonstration based on this being the maximum permitted airspeed below 10,000 ft altitude. However, there is ongoing activity to alter this restriction and this should be reflected in this proposed condition if the condition is retained.

5. Section 8.2: Positive indication of normal start progression should be sufficient to demonstrate acceptable windmill starting capability. The time requirements should be removed from this section.

6. Section 8.3: The proposed fuel interruption of "not less than 30 seconds" for rapid relight demonstration is inconsistent with the proposed recognition times under Section 7, Item 1 (5-15 seconds) and Section 7, Item 4 (30 seconds or less), where rapid relight is an acceptable means of compliance. The fuel interruption or recognition times from Section 7 should be used in Section 8.3.

7. Section 8.3: Text proposes rapid relight demonstrations should be performed with "engine initially stabilized at idle." There seems to be no justification for setting the engine power at "idle."

8. Section 8.6(b): The text "the engine should relight and reaccelerate to its original power without any crew actions other than selecting ignition and fuel" assumes a particular cockpit design. This text should be deleted.

E&S remains committed to the development of a regulatory requirement for all engines out in-flight restart. However, due to the concerns outlined above, we can not support the current proposal at this time. Instead, we recommend that this project be removed from the fast-track process and tasked as a full, cooperative government-industry rule-making project. Furthermore, this rule should not be implemented without regulatory harmonization with the Joint Airworthiness Authorities (JAA).

Sincerely,

Bill Moring

Bill Moring
Engineering Manager
Airworthiness and Certification
AlliedSignal Engines and Systems

WCM/sd

SUBJECT: Cessna Minority Position on Draft AC/ACJ 25.903(e)

DATE: August 19, 1999

TO: **P. Sallee**

FROM: **B. Miles/R. Barnes**

cc: R. Girardo
N. Anderson

The Cessna minority position on this AC/ACJ addressing in-flight restarting is as follows:

A. Revise Section 4.1 paragraph discussing 25.903(e) compliance as follows for accuracy:

Change " many turboprop airplanes utilize electric starters" to "many smaller turboprop and turbojet/turbofan airplanes utilize electric starters".

Change "and utilize pneumatic starters" to "and larger turboprop and turbojet/turbofan engines utilize pneumatic starters:.

B. In Section 5, based on the definitions of relight and restart in a) and b), change "Relight Envelope" to "Restart Envelope" in c) and d) to better reflect the intended meaning.

C. For Section 7 Condition I, Minimum Clean configuration speed is not a well defined or universally recognized speed. It is not believed that it is intended or appropriate to require extremely low speeds such as in or near the stickshaker regime. Since the airplane will be out of the airport environment, by virtue of the allowable 2500 foot altitude loss, and since the restart attempt may not occur until a second engine shutdown following an earlier first engine shutdown, it is requested that Minimum Clean Configuration speed be changed to V_{ENR}.

D. In Section 7, Condition I, clarification is requested as to whether the demonstration altitude should be the most critical altitude selected by the applicant, or whether multiple altitude demonstrations are required.

E. In Section 7, clarification is requested as to whether Condition III consists of both a climb and descent condition, or either a climb and descent condition, whichever is determined to be more critical.

F. In Section 7, Conditions II, III (descent), and IV, the power or thrust at shutdown needs to be clarified. It could be interpreted as either idle or typical descent power or thrust.

G. In Section 7, para 4) allows consideration of other factors, such as dedicated engine shutdown indication, aircraft design features which minimize the potential for inadvertent shutdown, or automatic relight and automatic sub-idle recovery systems, for evaluation of crew recognition time for condition IV. Other than dedicated engine shutdown indication, these factors have little to do with crew recognition time, rather they prevent the shutdown or the need for a flight crew initiated restart if they work properly. The intent of this guidance is unclear. Since these provisions can provide superior safety to crew procedures in low altitude situations, it is recommended that they be recognized as an alternative to low altitude all engine restart, providing they are appropriately addressed per 25.901(c)/25.1309. These factors and the comments above are equally applicable to condition I.

H. In Section 7, Condition IV, the 250 KCAS maximum airspeed should be deleted as unnecessary and redundant to other requirments, in particular the altitude loss. The 250 KCAS speed limit may not be applicable in all parts of the world, and is certainly a trivial operational consideration in an all engine out emergency situation compared to the necessity of a restart. It is recognized that higher speeds may not be practical for all aircraft, while still meeting the other requirements, but this should be an application specific issue rather than a blanket requirement.

I. In Section 8.1, the statement that sufficient tests must be carried out to validate the start envelope reliably is likely to lead to disagreement as to what is sufficient. An additional related issue is whether the engine is required to start successfully the first time, every time, especially at high altitudes exceeding the AC requirments and/or when starting with latent failures present such as an ignitor failure. The following additional guidance is suggested to address these issues.

Three demonstrated starts are normally sufficient at critical points in the starting envelope, however only one need be a simulated all engine out situation where altitude loss is measured. Critical points generally involve low airspeeds, high altitudes, or high ITT/EGT at start initiation. One demonstrated start is sufficient at other points. More than one start attempt, either automatic or manual, is acceptable, provided that the specified altitude loss is not exceeded, that adequate crew recognition of the unsuccessful start attempt is available, and that any external energy source used is not depleted. Multiple start attempts in situations where compliance with altitude loss requirements is marginal may require additional demonstrations to ensure consistency.

J. In Section 8.3, The guidance for rapid relight starts with 30 second recognition delay and idle power at engine shutdown should be revised to be consistent with the rapid relight conditions specified for Section 7 Condition I takeoff scenario.

Saint-Martin, 13 September, 1999
AI/EV-T 474.0646/99/JJO/SC

AI/EV-T

TO

BOEING Propulsion - G.P. SALLEE
AI/LE-P – JC. TCHAVDAROV
FAA - M. KASZYCKI

SUBJECT : LATEST DRAFT ON INFLIGHT RESTART ACJ

The draft ACJ on inflight restart produced by the AIA/AECMA group has been recently amended to take into account JAA comments. One paragraph has been added concerning the requirements that the APU must satisfy in terms of restarting reliability if it is used as a means of compliance for main engine inflight restart.

In the ACJ, an APU restart is considered successful if it is achieved in 2 attempts at the most (see attachment 1).
This is different from the definition of a successful APU restart in the context of ETOPS, where 3 attempts have been allowed, explicitly by the French Airworthiness Authorities (see attachment 2) and implicitly by the FAA (see attachment 3).

I see no benefit for having 2 different definitions of a successful APU restart, one for ETOPS and another one for engine airstart, and I would recommend that we harmonize according to the ETOPS rule, unless somebody comes up with a good reason to do otherwise (Sorry for reacting so late but I wanted to get the attachments and they were not in my possession).

Regards,

J. JOYE

ARAC - PPIHWG
Airbus / Aerospatiale Comments on the "Package"

JAR/FAR 1 – FIRE PROOF/RESISTANT DEFINITIONS REPORT

1st page, last paragraph : not only Titanium, but also some Steels could be in the same situation. (Same remark on 3rd page, end of 2nd paragraph).

1st page, last paragraph, last sentence : add ".... will maintain **sufficient** load carrying capability..."

3rd page, 3rd paragraph : with respect to "perform their intended function", current work on AC 25.865 (2001 ?) should be in line with our efforts.

Para 5 : should be "minimum **capability during a defined time period**", and not "minimum time period".

Para 13 : "No", we need also an AC on "perform their intended function".

25.901(d) – APU REPORT

Delete Title "Harmonization ... ... Appendix I".

1st Paragraph : with respect to essential APUs, the wording should include "... **only if necessary for the dispatch of the aircraft to maintain safe aircraft operation**."

1st Page bottom and second page top : The european rule is JAR "**Subpart J**" and not JAR-J.

Para 12/13/14 : Action for APU Team members. *(H D Hansen's letter sent to Team members).*

25.903(d)(1) – BURNTHROUGH REPORT + AC

Para 6.C : Definition of "Continued Safe Flight and Landing" : should be consistent with 25.1309 definition, we have not to invent something different.

15 ° aft trailing edge of last HPT blade : although this definition is very clear, we believe that the threat of 3000°F is too severe between combustor end and this point when no specific indications are given by the Engine Manufacturer for the application under certification.

25.903(e) – RESTART REPORT + COMMENTS

No specific comment on the Report. The draft AC is in some areas stronger than it should be as an interpretative material : an example is the compliance to be shown by test or analysis supported by test, whereas the rule leaves the choice of demonstrating by analysis or test.

AI (J. Joye) comment agreed by the Steering Committee in Montreal, to be included in the AC.

GE (Sara Knife) comment rejected by the Steering Committee in Montreal. In general AI/AM-B disagree with most GE comments.

Most of the Cessna comments (B, D, E, G, H, J) are judged good by AI/AM. Those can certainly be incorporated without altering the technical content of the AC.

P&W comments are more controversial. To AI/AM-B, the 3 first items of "Rationale" are not relevant : 1 and 2 are useless polemics, 3 is not true (the proposed language is not any more vague than so many rules !), 4 can be discussed (see first comment here above). Then, the P&W technical comments are addressed as follows :

- 1 is details,
- 2 can be accepted,
- 3 is okay, it is proposed that the text in section 7 be modified to be consistent with section 6.1,
- 4 could be discussed,
- 5 : green dot, holding speed,
- 6 can be discussed when relevant,
- 7 : see below (*),
- 8 : comment not understood,
- 9 could be discussed,
- 10 is agreed.

Finally, AI/AM-B disagree with P&W position that the task should be removed from the Fast-Track process to be tasked as a full rule-making process.

(*) With respect to the noticed discrepancies in Section 7, Paragraph 4 (see below), this text was modified during the last AIA/AECMA meeting in Seattle (July 98) in order to reach a consensus with the small engine manufacturers. A simple way to restore the coherence of the text is to go back to the pre-Seattle version as shown just below.

"4) **Flame out or shut down from descent power below 10,000ft with a delay in crew action based on indications (inherent or dedicated indicators) to the flight crew of all engine power loss.**
A 30 second crew recognition time should be used if no dedicated indication is provided. Crew Recognition Time may be shortened based upon dedicated indications that engines have flamed out or rolled back to sub-idle.~~, as well as aircraft design features which minimize the potential for inadvertent shutoff. Other factors which may be considered in the crew recognition time evaluation include automatic relight and automatic sub-idle stall recovery systems.~~
The initial airplane speed that should be used for the all-engine out restart evaluation is 1.45V stall (clean configuration) of the maximum landing weight of the aircraft. Acceptable means of compliance include rapid relight, starter assistance from an external
source and stabilized windmill start. The airplane should not lose more than 5000 feet altitude between initiating restart procedures and achieving level flight. In addition, the maximum aircraft speed to achieve the restart should not exceed 250kts."

25.905 – PROPELLER BLADE RELEASE REPORT + AC

No specific comment.

25.933- THRUST REVERSER Package

No Further Action.

25.934 – THRUST REVERSER TEST REPORT

JAR E Reference is **890** (and not 810) : 7 times in the document.

25.943 – NEG G REPORT + AC

Page 3 : JP4 is not necessarily always the most critical case for pump cavitation issue.

Page 4, Procedure : the 1st two conditions represent 7 and 5 seconds respectively; the total being 20 s, what should be the procedure for the last remaining 8 seconds ?

AI/BAe comment : the procedure as per ACJ 25X1315 is currently utilized by Airbus and approved by the FAA. What is the need to go to the proposed procedure ? As a compromize, if required, why not to propose to leave to the applicant the choise between one procedure (FAA AC25-7) or the other (JAA ACJ 25X1315), the 2 procedures being considered equivalent.

Para 7 : **add 25.943.**

Report Para 2 : add **JAR 25A943 and its ACJ.**

Report Para2 : correct JAR 25**X**1315 and not 25.1315.

25.1091 – WATER INGESTION TEST REPORT

Para 1 : "**recommends**" instead of "….is mandatory and requires…".

Para 6 : Delete current text. "**JAR/FAR Rule is harmonized. Advisory Material to be harmonized with JAA ACJ.**"

Para 7 : "**advisory material**" instead of "requirements" at the end of the text.

Para 12 : "**None**" instead of the current text.

Para 13 : "**No. The JAA ACJ 25.1091(d)(2) should be adopted.**"

25.1093 - FALLING AND BLOWING SNOW REPORT +AC

1st page, B.1 : correct "JAR 25…."

ACJ Para 2.f.1) : add "**If potential snow accumulation sites are identified, then the assessment should be expanded to include 2) and 3) below**."

25.1141 - POWERPLANT CONTROLS REPORT

Para 6 : The "Preferred" proposal is preferred by Airbus/Aerospatiale.

Para 6 : The text in italics after the rule ("*In addition, preamble material should .... 1) 2) 3)...*" should be not in the preamble, but in a short AC/ACJ to be written.

25.1189 - FLAMMABLE FLUID SHUT-OFF REPORT +AC

AC Last page, last sentence : replace current text by the following "**<u>If the analysis of drainage rate, per the guidance of AC 25.1187, shows that the fluid volume will drain within an additional 5 minutes, then fluid quantity can be considered to be non-hazardous without further hazard assessment.</u>**"

Appendix I – ATTCS REPORT + COMMENTS

No specific comment.

Airbus Industrie / Aerospatiale-Matra Airbus (AI/AM-B)
November 4, 1999

k) Rapid Relight/Quick Windmill Relight : A procedure in which the pilot executes a windmill start shortly after the engine has been shut down, so that the core speed is significantly above stabilized windmill speed.

6 - DESIGN CONSIDERATIONS

6.1 - Auto-adaptive systems

Several manufacturers have implemented features which are intended to enhance safety by reducing the likelihood of engine damage during start or eliminating all engine flame-out events for specific causes. These systems may improve safety but should not be considered as eliminating the need for a safety evaluation of all engine power loss occurrences. The following are methods Airworthiness Authorities are currently aware of :

Autostart Systems :

This feature is intended to protect the engine from damage due to a hung start. These systems are typically software controlled (FADEC) and monitor the engine start to assure limits are not exceeded during the start sequence. Typically fuel flow is interrupted ("depulsed") if the Exhaust Gas Temperature (EGT) reaches the defined limit. No specific indication may be provided to the crew that the depulse feature has been activated, however the crew may detect its activation by monitoring fuel flow, EGT and rotor speeds. This system will attempt multiple restarts inflight unless the crew intervenes and switches to the manual mode or the system will alert the crew if it discontinues attempts to restart the engine.

Auto Relight Systems :

These systems typically activate the engine ignitors if the engine rapidly decelerates and a reduction in engine combustor pressure (or EGT/fuel flow below specified levels) is sensed. These systems are generally used to recover from engine flameout in turbulent conditions and inclement weather.

6.2 - Cockpit Indications

Service history has shown that in some instances flight crews have not been aware that the engine was below idle power until the engine failed to respond when the throttle was advanced.

Conversely, during engine airstarts, flight crews have aborted start attempts that would have been successful, or shut down engines that had successfully reached idle. As a consequence :

1) Consideration should be given to providing the crew with indication(s) that the engine has flamed out and/or is at a sub-idle condition.

2) Consideration should be given to providing the crew with indication(s) that inflight restart is progressing normally in addition to indications of start faults.

3) Consideration should be given to providing the crew with indication(s) that the engine has reached idle following an inflight restart.

7 - COMPLIANCE GUIDANCE

This section is intended to define overall restart performance that includes the use of power assisted and windmill restart capabilities and to describe acceptable compliance guidelines.

DRAFT 8/16/99

PPIHWG Report on 25.903(e) – Inflight Starting

1. What is the underlying safety issue addressed by FAR/JAR? *[Explain the underlying safety rationale for the requirement. Why does the requirement exist?]*

The total loss of all propulsive power, malfunction of all engines installed on an airplane, for environmental, human error and other causes has occurred. The actual capability to inflight restart one or more engines, after all engine flameout or are shutdown, has provided the capability to avoid forced landings and the potential for severe consequences. However, engine certification standards are silent on a requirement to demonstrate a minimum inflight engine re-starting capability. The airplane certification requirements, whilst requiring that an inflight re-starting capability be demonstrated, do not establish a minimum standard for the required capability in terms of altitude, altitude loss and airspeed range given all engines have been lost. Lack of an explicitly defined inflight re-starting minimum safety standard has resulted in wide variation in the inflight engine re-starting capabilities. Some turbine engine types have no inflight windmilling re-starting capability at all and alternate means for inflight re-starting have been required under special condition. This regulatory proposal present in this Report is to amend the regulation to clearly address the all engine out failure condition and provide a minimum inflight re-starting capability to be achieved and a means to demonstrate compliance by the addition of a new rule and associated advisory material.

2. What are the current FAR and JAR standards? [*Reproduce the FAR and JAR rules text as indicated below.*]

"FAR part 25.903(e)
Restarting capability. (1) Means to restart any engine in flight must be provided (2) An altitude and airspeed envelope must be established for in-flight engine restarting, and each engine must have a restart capability within that envelope. (3) For turbine engines powered airplanes, if the minimum windmilling speed of the engine following the inflight shutdown of all engines, is insufficient to provide the necessary electrical power for engine ignition, a power source independent of the engine-driven electrical power generating system must be provided to permit in-flight engine ignition for restarting."

JAR 25.903(e) is identical to the FAR wording except for a reference to ACJ 25.903(e)(2) in the second subparagraph.

This Report proposes to adds a new 25.903(e)(4) requirement and associated Advisory Material.

3. What are the differences in the standards and what do these differences result in? [*Explain-the differences in the standards, and what the differences result in relative to (as applicable) design features/capability, safety margins, cost, stringency, etc.*]

The are no differences in the stated standard as shown in #2 above. Both standards do not adequately describe the minimum inflight restarting envelope of airspeed and altitude standard to be demonstrated given an all engines out situation (and no capability to use starter assist using pneumatic power from other engines on the airplane). Further the current standards to not provide a performance standard to be achieved with respect to altitude loss during the inflight re-start.

4. What, if any, are the differences in the means of compliance? [*Provide a brief explanation of any differences in the compliance criteria or methodology, including any differences in either criteria, methodology, or application that result in a difference in stringency between the standards.*]

A proposed means of compliance is provided in the associated Proposed AC.

5. What is the proposed action? [*Is the proposed action to harmonize on one of the two standards, a mixture of the two standards, propose a new standard, or to take some other action? Explain what action is being proposed (not the regulatory text, but the underlying rationale) and why that direction was chosen.*]

The proposed action is to establish a new rule and means of compliance which directly deal with the safety concern.

6. What should the harmonized standard be? [*Insert the proposed Text of the harmonized standard here.*]

See attachments – draft NPRM, rule and advisory material.

7. How does this proposed standard address the underlying safety issues (identified under #1? [*Explain how the proposed standard ensures that the underlying safety issue is taken care of.*]

The proposed rule requires that the "all engine out failure conditions" be addressed under four critical conditions likely to be encountered in service. Performance based success criteria concerning altitude loss during inflight re-starting is described. Additionally, the entry conditions for each in-flight restarting demonstration are defined. Given the airplane is demonstrated to have this engine restarting capability the safety objective, of minimizing the hazard associated with all engine out conditions, will be achieved

8. Relative to the current FAR, does the proposal increase, decrease or maintain the same level of safety? Explain. [*Explain how each element of the proposed change to the standard affects the level of safety relative to the FAR. It is possible that some portions of the proposal may reduce the level of safety even though the proposal as a whole may increase the level of safety.*]

Adoption of the proposal will increase safety relative to the current rule but is neutral given the current Generic Special Condition issued against all new airplane types for this safety concern.

9. Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain. [*Since industry practice may be different that what is required by the FAR (e.g., general industry practice may be more restrictive), explain how each element of the proposed change to the standards affects the level of safety relative to current industry practice. Explain whether current industry practice is in compliance with the proposed standard.*]

The proposal maintains current practice.

10. What other options have been considered and why were they not selected? [*Explain what other options were considered and why they were not selected (e.g., cost/benefit, unacceptable decrease in the level of safety, lack of consensus, etc.)*]

The proposal was developed at the request of the FAA toAIA as a AIA/AECMA activity/project. The completion of this Industry Project led to a petition for rule making. The current proposal makes use of the AIA/AECMA proposal amended to incorporate some JAA and JAA-PPSG (Powerplant Study Group) comments.

11. Who would be affected by the proposed change*?*[*Identify the parties that would be materially affected by the rule change – airplane manufacturers, airplane operators, etc.*]

Airplane manufacturers, STC applicants for installation of a different engine type on an airplane, and engine manufacturers.

12. To insure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble? [*Does the existing advisory material include substantive requirements that should be contained in the regulation? This may occur because the regulation itself is vague, or if the advisory material is interpreted as providing the only acceptable means of compliance.*]

None. The added rule and supporting AC/J require no other changes. However, the preamble to the rule should clearly define that the AC contains interpretative material intended to establish the minimum safety standard.

13. Is the existing FAA advisory material adequate? If not, what advisory material should be adopted? [*Indicate whether the existing advisory material (if any) is adequate. If the current advisory material is not adequate, indicate whether the existing material should be revised, or new material provided. Also, either insert the text of the proposed advisory material here, or summarize the information it will contain, and indicate what form it will be in (e.g., Advisory Circular, policy, Order, etc.)*]

Not applicable – The new rule and advisory material are additive and do not interfere.

14. How does the proposed standard compare to current ICAO standard? [*Indicate whether the proposed standard complies with or does not comply with the applicable ICAO standards (if any).*]

Help! FAA/JAA to answer.

15. Does the proposed standard affect other HWG's? [*Indicate whether the proposed standard should be reviewed by other harmonization working groups and why.*]

No.

16. What is the cost impact of complying with the proposed standard? [*Is the overall cost impact likely to be significant, and will the cost be higher or lower? Include any cost savings that would result from complying with one harmonized rule instead of the two existing standards. Explain what items affect the cost of complying with the proposed standard relative to the cost of complying with the current standard.*]

Cost implications have already been addressed by the Generic Special Condition and given that the Special Condition was considered necessary the new rule and AC only clarify and standardize the requirements and no additional cost should be involved.

17. Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

Yes.

18. In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rule making project, or is the project too complex or controversial for the Fast Track Process. Explain? Explain. [A negative answer to this question will prompt the FAA to pull the project out of the Fast Track Process and forward the issues to the FAA's Rulemaking Management Council for consideration as a "significant "project.]

. *Yes*

Revision dated 8/12/99

AC / ACJ 25.903(e)

ENGINE RESTART CAPABILITY DEMONSTRATION FOR TRANSPORT CATEGORY AIRPLANES

1 - PURPOSE

This Advisory Circular (AC) provides information and guidance concerning a means, but not the only means, of compliance with section 25.903(e) of Part 25 of the Federal Aviation Regulations (FAR) which pertains to engine restart capabilities of Transport Category Airplanes. Accordingly, this material is neither mandatory nor regulatory in nature and does not constitute a regulation. In lieu of following this method, the applicant may elect to establish an alternate method of compliance that is acceptable to the Federal Aviation Administration (FAA) for complying with the requirements of the FAR sections listed below.

2 - SCOPE

This Advisory Circular provides guidance for a means of showing compliance with regulations applicable to engine restart capability in Transport Category Airplanes. This guidance applies to new airplanes designs as well as modifications to airplane or engine designs that would adversely affect engine restart capabilities.

3 - RELATED FARs and JARS

FAR Part 25, sections, 25.903(e), 25.1351(d), 25.1585(a)(3), JAR 25.903(e), JAR-E910, FAR 33.5(b)(3) and 33.89(a)(1).

4 - BACKGROUND

4.1 - Regulatory history

The inflight engine restart requirements for turbine powered airplanes are identified in §§§ 25.903 and 25.1351 and 25.1585 of the Federal Aviation Regulations (FAR). Sections 25.903 and 25.1585 requirements were developed from the engine inflight restart requirements of the earlier Civil Air Regulations (CAR) Part 4b. Paragraph 4b.401(c) required the ability for individually stopping and restarting the rotation of any engine during flight.

This intention was further incorporated into Part 25, specifically § 25.903(e), which requires 1) the ability to restart any engine during flight must be provided; 2) an altitude and airspeed envelope must be

established for inflight engine restarting, and each engine must have a restart capability within that envelope; and 3) if the minimum windmilling speed of the engines following the inflight shutdown of all engines, is insufficient to provide the necessary electrical power for engine ignition, a power source independent of the engine driven electrical power generating system must be provided to permit inflight engine ignition for restarting. In addition, Section 25.1351(d) requires demonstration that the airplane can be operated for 5 minutes following the loss of all normal electrical power (excluding the battery) with the critical type fuel (from the standpoint of flame out and restart capability) and with the airplane initially at the maximum certificated altitude. For airplanes equipped with Alternating Current (AC) powered fuel pumps that are powered from the engine electrical generators, this requirement has resulted in demonstration of the capability to windmill relight the engine while on suction feed with battery power for ignition. Relight of the engines has typically occurred at altitudes between 16,000 and 25,000 feet. In addition, as stated earlier in CAR 4b.742(d), the recommended procedures to be followed in restarting turbine engines in flight are to be described, including the effects of altitude.
This intention was also incorporated into Part 25, specifically § 25.1585(a), which states that information and instruction must be furnished, together with recommended procedures for restarting turbine engines during flight (including the effects of altitude).

There are no explicit inflight restarting requirements imposed on the engine in FAR 33 or JAR-E. Nevertheless there are requirements to define starting procedures (33.5(b), **33.89, E910) and to recommend an envelope (E910).**

Compliance with § 25.903(e) has been shown by establishing that adequate engine restart capabilities exist for the various engine types installed on transport category airplanes.
For example, many turbopropeller airplanes utilize electric starters that allow restart of the engine throughout the airplane airspeed and altitude flight envelope. Compliance is therefore easily shown by flight test demonstration of restart capability and analysis to show availability of electrical power for the starter. Turbo jet/turbo fan engines typically have windmill restart capability that is effective throughout a portion of the flight envelope, and utilize pneumatic starters to achieve restart throughout the remainder of the envelope. Compliance demonstration for these airplanes have included establishing both a windmill and a starter assist restart envelope. In several instances the windmill restart envelope has been limited to a small portion of the flight envelope. Applicants have utilized supplemental restart means, such as an essential APU installation to supply pneumatic power for restart to substantiate compliance.

Lack of an explicitely defined inflight restarting minimum standard has resulted in wide variations in the restart capabilities of transport category airplanes. Some newer technology engines require several minutes at airspeeds above 250kts to windmill restart.

In addition, some turbopropeller engines with free turbines have limited or no windmill restart capabilities within the normal airplane operating envelope. On certain airplane types that are not equipped with means to assist restart, reduced engine restart capabilities could result in an unsafe condition following an all-engine flame out event at mid to low altitudes.The altitude loss required to obtain sufficient airspeed for a windmill restart, in conjunction with the associated long restart times, may not allow restart prior to reaching ground level.

4.2 - Service History

Since the beginning of aviation, all-engine power loss incidents have occurred. Incidents have been reported on almost every airplane type for various reasons such as fuel mismanagement, loss of electrical power, crew error, mis-trimming of engine idle setting, fuel nozzle coking, volcanic ash encounters, and inclement weather. The FAA has determined that the all-engine power loss event must be considered in airplane design.

Section 25.671 requires that the flight controls be designed such that control of the airplane can be maintained following the loss of all engine power. The service experience supports the position that suitable engine restart capability must be available following the loss of all engine power to avoid an unsafe condition.

4.3 - Industry Restart Data

Industry historical records contain many (at least 30 events in the period 1982 up to 1993) multiple engine power loss events.
These records show all-engine power loss events that jeopardized continued safe flight have occurred (over the altitude range) for the following reasons :

Weather	(Low Altitude to FL410)
Volcanic Ash	(FL370, FL330, FL250, low altitude possible)
Crew error	**(FL030 to FL410)**
Compressor Surge	(Takeoff to cruise altitude)
Maintenance Error	(Takeoff to cruise altitude)
Other/Unknown	(Takeoff to cruise altitude)

It does not appear that it is possible to define in advance all of the potential causes for critical power loss and/or preclude their occurrence. Thus it is necessary to define what engine restart capabilities are required to maintain the current level of safety.

5 - DEFINITIONS

a) Relight : The combustor lights off and sustains combustion.

b) Restart : The engine has accelerated to stabilized flight idle.

c) Windmill Relight Envelope : The portion of the airplane airspeed/altitude envelope where the engine is capable of being restarted without starter assistance.

d) Power Assisted Relight Envelope : The portion of the airplane airspeed/altitude envelope where the engine requires starter assistance to achieve restart.

e) Auto Ignition System : A system that automatically activates the engine ignitors if pre-determined conditions apply (e.g., ice detectors indicate icing conditions, flaps are configured for approach/landing, etc.).

f) Auto Start System : A system that monitors engine parameters during starting and automatically sequences fuel flow accordingly. It may include logic protecting against turbine temperature limit exceedance and sub-idle stall, among other features.
It reduces pilot work load by eliminating the need to manually turn fuel on at a given core speed and to monitor the speed/turbine temperature relationship during the start.

g) Auto Depulse Logic/Stall Recovery Logic : Logic incorporated into the engine control that momentarily shuts off fuel flow to clear an engine stall.

h) Auto-Relight : A feature which monitors the operation of the engine to attempt to recover an engine flameout. In its most basic form, it is equivalent to automatically selecting continuous ignition. When the engine control senses that an engine has flamed out (by rotor speed decay, a drop in combustor pressure, or other means), it turns on the ignitors.
Auto-relight typically reacts much more quickly to a flame out than a pilot could.

The effects of the loss of engine power from one, multiple and all engines must be considered. However, the loss of all engines generally determines the most stringent requirements in terms of restart capability, and the intent of the regulation will be satisfied by addressing this critical case.

In order to confirm that engine restarting can be achieved, in circumstances where all engines run down or are shut down, the applicant will be expected to show by test or analysis supported by tests that sufficient power/thrust can be restored to enable the airplane to achieve level flight without excessive loss of altitude.

Four conditions are to be addressed :

1) Shut down from take off/climb power with pilot recognition time delay based on analysis of indications (inherent or dedicated indicators) to the flight crews (Pilot recognition time has typically ranged from 5 to 15 seconds based on service data).
Acceptable means of compliance include rapid relight procedures or starter assistance from an external power source. The altitude loss between initiating the restart and achieving level flight should not exceed 2500ft.

2) An engine should be able to be restarted at a minimum altitude of 15,000ft from a shut down at typical descent speed at 20,000ft or above.

3) The engine should be able to be restarted with an altitude loss not exceeding 5000ft from a power loss occurring between 10,000 and 20,000 feet.

   The aircraft speed at the time of power loss should be representative of the normal flight profile (climb or descent) in this altitude range for the flight phase considered.

4) Flame out or shut down from descent power below 10,000ft with a delay in crew action
based on indications (inherent or dedicated indicators) to the flight crew of all engine power loss.
A 30 second crew recognition time should be used if no dedicated indication is provided.
Crew Recognition Time may be shortened based upon dedicated indications that engines have flamed out or rolled back to sub-idle, as well as aircraft design features which minimize the potential for inadvertent shutoff. Other factors which may be considered in the crew recognition time evaluation include automatic relight and automatic sub-idle stall recovery systems.
The initial airplane speed that should be used for the all-engine out restart evaluation is 1.45V stall (clean configuration) of the maximum landing weight of the aircraft.
Acceptable means of compliance include rapid relight, starter assistance from an external source and stabilized windmill start. The airplane should not lose more than 5000 feet altitude between initiating restart procedures and achieving level flight. In addition, the maximum aircraft speed to achieve the restart should not exceed 250kts.

These compliance guidelines are summarized in a tabular form here below :

	I TAKE OFF	II HIGH ALTITUDE	III CLIMB/DESCENT	IV LOW/SLOW
INITIAL ALTITUDE	Approved Takeoff Altitude Range	20 kft +	10 to 20 kft	10kft to landing

8.6 - Additional compliance demonstrations

As a complement to the compliance demonstrations carried out to establish and validate the declared airstart envelope, the capability to restart the engine should be demonstrated in the following particular cases :

a) Restart after engine cold-soak

Some restarts should be carried out within the declared restart envelope after shut down periods of 5 minutes and 15 minutes.

b) Immediate restart after shut down from high power

- The capability to immediately restart the engine after a shut down from max climb power following a take-off should be demonstrated.

- If the means of compliance is a quick relight procedure, the fuel interruption should last typically 5 to 15 seconds depending on indications available to the crew (as stipulated in section 7), and the engine should relight and reaccelerate to its original power without any crew actions other than selecting ignition and fuel.

c) Restart after suction feed flameout

For airplanes equipped with AC powered booster pumps, the effect of the loss of all normal AC power should be tested.

The test should be conducted using the worst case fuel from an engine flame-out standpoint.
If the fuel volatility is greater than that of Jet A/Jet A1, the fuel should be preheated in mass such that the fuel temperature in the aircraft tank is at least 110° F after refueling.

The capability to restart engines should be demonstrated when the suction feed flame-out occurs at the maximum cruise altitude, and also at the maximum suction feed climb altitude if no alert is provided to deter the crew from climbing above it when operating in gravity feed conditions.

For the maximum cruise altitude case, the test should consist of a straight climb to the aircraft ceiling altitude, where the loss of AC power will be simulated for one engine. If flame-out occurs, the restart of the engine should be attempted with the aircraft configured to be representative of an all engine flame-out condition.

For the suction feed climb case, the loss of AC power should be simulated for one engine immediately after take-off and a continuous climb performed until the engine flames out. The restart should be attempted with the aircraft configured to be representative of an all engine flame-out condition.

For both cases, a successful restart should be achieved prior to reaching 10000ft if the fuel volatility is greater than that of Jet A/Jet A1, or 15,000ft with all others.

ALTITUDE LOSS *	2500 ft	Relight by 15kft	5000 ft	5000 ft
MAX ALLOWABLE AIRSPEED	N/A	N/A	N/A	250 KTS (based on max airspeed below 10 kft)
INITIAL AIRSPEED	***Minimum Clean Configuration*** speed or 250 kts **	Typical descent speed	Normal flight profile (climb or descent speed)	1.45 V stall (clean airplane config.)
RECOGNITION TIME	typically 5 to 15 seconds	N/A	N/A	30 seconds or less depending on indications
ACCEPTABLE MEANS OF COMPLIANCE	Rapid relight or assisted relight from an external source	Stabilized windmill start or starter assist from an external source	Stabilized windmill start or starter assist from an external source	Rapid relight, starter assist from an external power source or stabilized windmill start

* Note Altitude loss measured from initiation of restart procedure
** Note – the lesser of the two speeds

8 - COMPLIANCE DEMONSTRATION

8.1 - General

The restart envelope and procedures declared by the applicant are intended to fulfill the guidelines specified in section 7.

The declared restart envelope will generally consist of several zones.

- One zone where the engine is rotated by windmilling at a sufficiently high RPM to achieve a successful restart. This zone may be subdivided into a stabilized windmill restart envelope and a spooling – down restart envelope (rapid relight).

- Another zone where the engine is rotated with the assistance of a starter to a sufficiently high RPM to achieve a restart.

Each zone must be identified in the Airplane Flight Manual. Sufficient tests must be carried out in each zone to validate it reliably.

8.2 - Demonstration procedure for stabilized windmill airstarts

- Tests should be conducted so that the windmill speed of the test engine is fully stabilized when the target altitude and aircraft speed are reached.

- The engine fuel feed system, hydraulic system and electrical system should be configured to be representative of an all engine flame-out condition.

- The time to relight should not exceed 30 seconds and the spool-up time from relight to idle should not exceed 90 seconds. A longer spool-up time may be acceptable if a positive indication is available to the crew that the start is progressing normally. However the altitude loss associated with the total restart time (from fuel on to idle) in an all engine flame-out condition should not exceed 5000ft, when the restart is initiated at or below 20000ft (as stipulated in section 7).

8.3 - Demonstration procedure for spooling-down windmill airstarts (rapid relight)

- The declared rapid restart envelope should be based on a fuel interruption of not less than 30 seconds. A shorter time may be acceptable if a dedicated engine failure annunciation is provided to the crew.

- Tests should be conducted with the engine initially stabilized at idle. The engine should relight and accelerate to idle without requiring any crew actions other than selecting ignition and fuel.

- The same conditions as in § 8.2 above should be observed for the engine fuel feed system, hydraulic system and electrical system.

- The same criteria as in § 8.2 should be used for times to relight and spool-up.

8.4 - Demonstration procedure for starter-assisted airstarts

- Tests should be conducted so that the windmill speed of the test engine is fully stabilized when the target altitude and aircraft speed are reached.

- The engine fuel feed system, hydraulic system and electrical system should be configured to be representative of the condition of the airplane for the case considered.

- The same criteria as in § 8.2 should be used for times to relight and spool-up.

8.5 Demonstration procedure for APU assisted engine airstarts

If an APU assisted engine airstart is used for compliance with any of the section 7 restart conditions, the following guidelines should be followed:

- the APU installation should be certified as "essential"
- a minimum of a 95% APU start reliability must be demonstrated by test considering:
    i) maximum APU cold soak appropriate for restart condition being addressed (note that the APU coldsoak associated with the maximum airplane range should be considered for the high altitude cruise condition II and the descent condition IV)
    ii) a maximum of two APU start attempts shall be allowed for each start condition
    iii) continuous APU operation throughout the affected flight regime may be used in lieu of demonstrating APU inflight start reliability
- APU start time should be considered in the airplane altitude loss calculation
- In order to maintain the APU's demonstrated start reliability after the airplane is introduced into service, the airplane and APU manufacturer should develop a maintenance program for the APU installation. This maintenance program should include general APU maintenance tasks, periodic checks of the APU's inflight starting capability and a post-maintenance inflight start verification. The critical maintenance tasks, start functional checks, as well as their associated time intervals should be mandated. Consideration of including these items as Certification Maintenance Requirements should be given.
- if an APU assisted engine start is used for complying with the low altitude conditions I or IV (takeoff and descent/landing), then the airplane should incorporate logic which automatically recognizes the all engine powerloss condition and automatically restarts the APU. Further, consideration should be given to also automatically reconfigure the airplane pneumatic and/or electrical system to minimize the crew workload associated with achieving main engine restart during these critical low altitude conditions.

Recommendation Letter

Action: ARM-1

Pratt & Whitney
400 Main Street
East Hartford, CT 06108

Pratt & Whitney
A United Technologies Company

AVC-1 Signature

September 19, 2002

Federal Aviation Administration
800 Independence Avenue, SW
Washington, D.C. 20591

Attention: Mr. Nicholas Sabatini, Associate Administrator for Regulation and Certification

Subject: ARAC Recommendation, Automatic Performance Reserve

Reference: ARAC Tasking, FAA letter to C. Bolt, November 19, 1999

Dear Nick,

The Transport Airplane and Engine Issues Group is pleased to submit the following as a recommendation to the FAA in accordance with the reference tasking. This information has been prepared by the Powerplant Installation Harmonization Working Group.

- PPIHWG report – 25.904/Appendix I - Automatic Performance Reserve
- Proposed NPRM – Automatic Performance Reserve
- Proposed Advisory Material – Automatic Performance Reserve

Sincerely yours,

Craig R. Bolt

C. R. Bolt
Assistant Chair, TAEIG

Copy: Dionne Krebs – FAA-NWR
Mike Kaszycki – FAA-NWR
Effie Upshaw – FAA-Washington, D.C.
Andrew Lewis Smith - Boeing

Recommendation

ARAC WG Report

Report from the PowerPlant Installation Harmonization Working Group

Rule Section: FAR 25.904/JAR 25X20(c) and FAR/JAR 25 Appendix I

What is the underlying safety issue addressed by the FAR/JAR?: This appendix specifies additional requirements if an applicant elects to install an engine control system that automatically increases thrust or power on the operating engine(s) if an engine fails during takeoff. With such a system installed, takeoffs would normally be made with thrust or power set at less than the maximum takeoff thrust or power. If an engine fails, the system automatically increases thrust on the operating engine(s) to the maximum takeoff thrust or power.

Compliance with the additional requirements specified in the appendix for airplane performance, system reliability, initial thrust setting, powerplant controls, and powerplant instruments allows the takeoff power or thrust obtained after operation of the engine control system to increase power or thrust to be used to meet the part 25 one-engine-inoperative airplane performance requirements. By specifying these additional requirements, and recognizing that the use of reduced takeoff thrust reduces the probability of an engine failure, this appendix ensures that incorporation of such a system provides an equivalent level of safety to that intended by the basic part 25 requirements.

What are the current FAR and JAR standards?: see Appendix 3 & Appendix 4, respectively.

What are the differences in the standards and what do these differences result in?: The differences between the two standards and the effects of differences are summarized as follows:

1. In the FAR, the initial power setting used for takeoff may not be less than 90 percent of the maximum takeoff thrust or power approved for the airplane under the existing ambient conditions. The JAR does not limit the initial power setting, but limits the thrust that can be used to show compliance with the JAR-25 airplane performance requirements to no more than 111 percent of the initial power setting. The FAR standard is more stringent because it precludes taking credit for any performance benefit associated with the automatic thrust increase when the initial takeoff power setting is less than 90 percent of the maximum takeoff thrust. At an initial power setting of 90 percent of the maximum takeoff thrust, the two standards are equivalent in terms of the resulting performance credit granted, but the JAR allows credit for further reductions in the initial power setting while the FAR does not.

   The effect of this difference is that the takeoff weight of an airplane certificated to the FAR standards may be restricted to a lesser value relative to that available to an airplane certificated to the JAR standards when the initial thrust or power setting is less than 90 percent of the maximum takeoff thrust. The operator of an airplane certificated to the FAR standards may therefore realize a potential revenue loss due to a loss of payload-carrying capability compared to an operator of an airplane certificated to the JAR standards.

2. The JAR requires that inadvertent operation of the automatic system be either of a remote probability or have no more than a minor effect on safety. The FAR does not explicitly address inadvertent operation. The JAR standard is more stringent and requires a more reliable system design.

3. For airplanes equipped with limiters that automatically prevent engine operating limits from being exceeded under existing ambient conditions, a means other than normal use of the power or thrust levers may be used to manually increase power or thrust to the maximum power or thrust. The FAR is more stringent in that it requires that other means to be located on or forward of the thrust or power levers and that it meet the requirements of § 25.177(a), (b), and (c). The JAR only requires the other means to be in an accessible position on or close to the thrust or power levers. This rule difference can lead to differences in the placement of the means used to manually increase thrust or power between airplanes certificated under the different standards. This potential feature is no longer considered required and has been removed. The allowance was introduced to accommodate existing designs at the time the original rule was introduced.

4. The FAR uses the term "Automatic Takeoff Thrust Control System (ATTCS)" for such a system, while the JAA uses the term "Automatic Reserve Performance (ARP) System." This difference is in nomenclature only and does not affect the requirements or stringency of the standards.

5. Another editorial difference is that the FAR combines the performance and system reliability in one section, § I25.3, while the JAR separates these items into two paragraphs, JAR I25.3 and I25.4. As a result, the numbering of the succeeding paragraphs differ between the FAR and the JAR. Various other editorial differences exist as well, but they do not affect the application of the standards.

What, if any, are the differences in the means of compliance?: Except for the means of compliance associated with the differences in the standards, the means of compliance are the same.

What is the proposed action?: The proposed action is to harmonize the standards by using the least costly means of ensuring that the underlying safety issue is addressed. Also, the harmonized standard would be updated to include appropriate safety standards for additional capabilities that have been incorporated into more recent system designs for which the current FAR or JAR standards do not contain adequate or appropriate safety standards. In accordance with § 21.16, the FAA has issued special conditions for several airplane types to provide appropriate safety standards for these additional capabilities. These additional capabilities include the use of an engine control system to increase power when an engine fails during or prior to a go-around. The additional standards proposed here are based on those special conditions as well as similar special conditions issued by the JAA.

The changes addressed in this proposal are:

- Use of the term **Automatic Performance Reserve (APR)** as the harmonized name for a system that automatically resets power or thrust on the operating engine(s) when an engine fails during a takeoff or go-around. A majority of airplane and engine manufacturers has been using this term rather than the terms "Automatic Takeoff Thrust Control System (ATTCS)" or "Automatic Reserve Performance (ARP) System" used in the current FAA and JAA standards, respectively. In the proposed harmonized standard, "Automatic Performance Reserve (APR)" would replace "Automatic Takeoff Thrust Control System (ATTCS)" throughout § 25.904 and Appendix I to part 25, and replaces "Automatic Reserve Performance (ARP) System" throughout JAR 25X20(c) and Appendix I to JAR-25. This change would not affect the level of safety intended by the standards.

- **Harmonization of editorial differences.** As an editorial change, the current § I25.3, "Performance and System Reliability Requirements," would be split into two sections: § I25.3 "Performance Requirements," and § I25.4 "Reliability Requirements." The remaining current §§ I25.4 through I25.6 would be renumbered as §§ I25.5 through I25.7. For the most part, the harmonized standard would be based editorially on the current FAR standard. Miscellaneous editorial changes are proposed to improve clarity.

- **Use of APR for go-around.** As noted above, special conditions have been issued for several airplane types (e.g., BAe Systems Jetstream 41, CASA C-295, Dassault Falcon 2000, DeHavilland DHC8-400, Bombardier CRJ 700) to approve the use of an APR system for go-around. Use of such a system for go-around extends engine life and reduces the probability of an engine failure by allowing a lower power or thrust level to be set when conducting a go-around with all engines operating. If an engine fails during the go-around, the APR system will automatically increase power on the operating engine(s) to the go-around power or thrust setting without any action by the pilot. Installation of an APR system for go-around allows the use of the go-around power or thrust setting to be used to show compliance with the one-engine-inoperative approach climb requirements of § 25.121(d) even though a reduced power setting is used for normal operations (i.e., with all engines operating).

  Although APR for go-around is very similar to APR for takeoff, there are three important differences that cause the requirements applicable to takeoff, which are the standards currently included in appendix I, inadequate to address the safety issues associated with a go-around. First, a go-around may be initiated with an engine previously shut down or otherwise made inoperative, in addition to the case where the engine failure occurs during the go-around. Second, the I25.5(b)(3) requirement for a means for the flightcrew to verify before takeoff that the system is in a condition to operate does not ensure adequate reliability or flightcrew awareness regarding the operability of the system. Third, as noted in the preamble to Amendment 25-62 to 14 CFR part 25, which is the amendment that added Appendix I to part 25, flightcrew workload issues precluded expanding the scope of the standards to include phases of flight other than takeoff. The preamble specifically referred to go-around, where it was stated:

> "In regard to ATTCS credit for approach climb and go-around maneuvers, current regulations preclude a higher power for the approach climb (§ 25.121(d)) than for the landing climb (§ 25.119). The workload required for the flightcrew to monitor and select from multiple in-flight power settings in the event of an engine failure during a critical point in the approach, landing, or go-around operations is excessive. Therefore, the FAA does not agree that the scope of the amendment should be changed to include the use of ATTCS for anything except the takeoff phase."

To address these issues, the following changes to appendix I are proposed:

The critical time interval (CTI), during which it must be extremely improbable for the concurrent existence of an engine and APR system failure, would be redefined for the go-around case. The CTI for the go-around case would ensure that it is extremely improbable to violate a flight path based on the §/JAR 25.121(d) one-engine-inoperative approach climb gradient requirement. This critical time interval would take into account that the engine may be inoperative before initiating the go-around, or it may fail during the go-around.

The working group considered various methods for defining the CTI for go-around, including the methods used in the previously mentioned FAA special conditions as well as similar certification requirements for these systems that were established by the JAA and Transport Canada. In examining the different methods and their effects on APR system design, the working group found that a rigorous CTI definition is unnecessary. The CTI, as only one of the criteria used to establish the reliability requirements for the system, is not limiting for current or envisaged future designs. Another reliability criterion contained in the proposed harmonized standard, the consideration of the elapsed time since verification that the system is in a condition to operate, is always more critical than the CTI. For some APR system elements, verification of operability can only be performed prior to commencing the flight, so the elapsed time since verification includes the entire duration of the flight. The short duration of the CTI has a very minor effect on the overall time at risk and therefore on the calculated APR system reliability.

Because the CTI for go-around has little or no effect on the design of the APR system, it could be argued that there is no need to require it to even be considered. However, to retain consistency with the takeoff APR requirements, provide visibility to the issue, and to cover potential future designs for which the CTI could be a critical factor, the working group is not proposing to exclude a CTI value for go-around. Instead, the use of a single, conservative CTI value of 120 seconds is proposed. This value is more stringent than would be obtained through any of the more rigorous methods that have been used, but greatly simplifies the task of showing compliance. For comparison purposes, the CTI for the BAe Systems Jetstream 41 & Bombardier CRJ700 airplanes were determined to be 26 & 35 seconds respectively using the complex method specified in the FAA special conditions.

To address potential designs where the use of such a conservative CTI value would be unduly penalizing, the proposed standard would allow the use of a rational analysis to justify using a shorter time interval. An acceptable method for conducting a rational analysis would be provided in a proposed AC/ACJ (attached), and would be based on the method given in the FAA special conditions. Also, it should be pointed out in the preamble to the proposed regulatory amendment that since the basis of the proposed CTI value is that 120 seconds is conservative and not limiting, if it turns out that this value is not conservative and the rationally derived CTI would be limiting, then a rationally derived CTI must be used.

(1) This definition of the critical time interval for go-around would be added as a new §/JAR I25.2(b)(2). The current §/JAR 25.5(b) would be reformatted such that the definition of the critical time interval for takeoff would become §/JAR I25.2(b)(1).

(2) To address the issue of the verification of system operability, a new §/JAR I25.4(d) would be added to require the safety analysis to include consideration, as applicable, of an APR system failure occurring after the time at which the flight crew last verifies that the APR system is in a condition to operate until the end of the critical time interval.

(3) To address the crew workload issues, a new §/JAR 25.5(b) would be added to require, for approval of an APR system for go-around, the same thrust or power setting procedure to be used for go-around initiated with either all engines operating or with one engine inoperative. This requirement is intended to ensure the same flightcrew action is used to set go-around power or thrust regardless of whether or not an engine is inoperative. As stated in the preamble to Amendment 25-62, the flightcrew cannot be expected to select, set, and monitor from multiple power settings in the event of an engine failure during a critical point in the approach, landing, or go-around.

In addition to the change noted above, the following rule sections (as renumbered under the proposal to reformat the FAR to harmonize with the JAR) would be amended to reference go-around in order to make the requirements applicable to go-around if that capability is sought by the applicant: § 25.904 (JAR 25X20(c) would be removed), §/JAR I25.1(a), §/JAR 25.2(a), §/JAR 25.3(a), §/JAR 25.3(b), §/JAR I25.5(a), I25.5(b), §/JAR 25.6(b)(1), §/JAR 25.6(b)(2), and §/JAR 25.7(b).

- **Thrust or power setting**. The proposed harmonized standard would replace the FAR limitation that the initial thrust or power setting must not be less than 90 percent of the thrust or power set by the APR system after an engine failure with the JAR requirement that the thrust used to show compliance with the applicable one-engine-inoperative climb requirements not be greater than 111 percent of the thrust obtained at the initial thrust or power setting. Both standards are intended to ensure an adequate climb capability with all engines operating and to limit the degradation of performance if the critical engine fails and the APR system fails to apply maximum takeoff thrust or power on the operating engine(s).

  The FAR limitation was also driven by pilot workload concerns, similar to the workload concerns with extending APR capability to cover the go-around phase of flight. The preamble to Amendment 25-62 states:

  > "The FAA has not restricted ATTCS operations where airplane performance is based on an approved "derate" rating which has corresponding engine and airplane limits approved for use under all weight, altitude, and temperature (WAT) conditions. However, the FAA has not allowed the reduced thrust (assumed temperature or weight decrement method) operations to be combined with ATTCS because the resulting flight procedures would increase the pilot workload by creating an infinite number of initial all-engine and engine-failed thrust settings. The increased workload could lead to performance computation error, and create confusion for the crews' workload during a critical high workload engine failure situation. Operationally, noise abatement procedures have already created another set of thrust settings which must be monitored and set. The combination would substantially increase exposure to performance limiting condition, and this clearly would not be equivalent to current regulations, which are based on a single thrust setting for takeoff."

  Since the time that was written, the FAA has allowed reduced thrust operations with the APR system operating, but has not allowed the thrust or power increase provided by the APR system after an engine failure to be used to show compliance with the airplane performance requirements. The proposed harmonized standard would allow performance credit for a thrust or power increase limited to 111 percent of the initial thrust or power set at the beginning of the takeoff or go-around. A thrust or power increase of 111 percent is equivalent to the increase achieved in going from an initial setting of 90 percent to 100 percent of the thrust or power set by the APR system after an engine failure.

The pilot workload issue would be the same for an initial thrust or power setting of 89 percent of the maximum takeoff thrust or power as it would for an initial thrust or power setting of 90 percent. During the critical time interval it must be extremely improbable for a combined engine and APR system failure. This requirement provides sufficient time for the flightcrew to determine if additional thrust or power is needed in the event of a combined engine and APR system failure. Current § I25.5(b)(2), which would be redesignated § I25.6(b)(1) already requires that the system allow manual increase or decrease of the thrust or power up to the maximum takeoff thrust or power. There is no need for the flightcrew to determine and set the specific one-engine-inoperative thrust or power setting that would normally be set by a functioning APR system as long as the appropriate thrust or power setting limits are displayed on the relevant cockpit instrument displays.

- **Inadvertent operation**. The proposed harmonized standard would include the additional JAA requirement regarding the potential for: inadvertent operation. The current JAR I25.4(c) would be adopted as harmonized §/JAR I25.4(c).

- **Means to deactivate**. In recognition that modern FADEC controls have the APR system as an integral part of the control and hence abnormalities or apparent inadvertent operation indicates a basic control function fault or failure, a dedicated means to deactivate the APR system may not be required. Reducing power or thrust to idle or shutting down the engine may be the appropriate action. In the proposed harmonized standard, current § I25.5(b)(4) would be revised to indicate that a means to deactivate the automatic function need not be provided if it can be shown that such a means is unnecessary for safety. Typically, this would involve substantiation the APR system without a switch can comply with §§/JAR 25.1301 and 25.1309 and that a deactivation means will never be needed in order to maintain the same level of safety as would be present if a switch were available.

What should the harmonized standard be?: See below

Proposed text of harmonized standard: See Appendix 1.

How does this proposed standard address the underlying safety issue?: It continues to ensure that incorporation of such a system provides a level of safety intended by the basic Part 25 requirements, adopting the appropriate existing FAR/JAR standards and adding safety standards from applicable special conditions) issued for capabilities added since the standards were adopted.

Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety?: The proposed standard maintains the level of safety by incorporating existing accepted regulatory requirements and adds the JAR requirement relative to inadvertent operation of the system.

Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety?: It maintains the current level of safety since industry practice is to comply with both the FAR and the JAR, including any applicable special conditions.

What other options have been considered and why were they not selected?: The harmonization of the most stringent of the FAR / JAR material was considered for the 'fast track' process. This option was not pursued because it did not address the additional capability of APR for go-around. The majority of recently certificated aircraft with an APR system provide this capability and have required special conditions for airworthiness approval.

The group also considered addressing APR credit beyond the take-off / go-around power set regime (e.g., Climb power to Maximum Continuous power).
The group decided that this change could not be made within the schedule defined for the Fast Track Harmonization Program.

Who would be affected by the proposed change?: Manufacturers and operators of transport category airplanes and manufacturers of the engines and engine power control systems for those airplanes that automatically reset thrust or power on the operating engine(s) in the event of the failure of an engine could be affected by the proposed change.

To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble?: None.

Is existing FAA advisory material adequate? (If not, what advisory material should be adopted?): Existing advisory material in Advisory Circulars 25-13 and 25-7A would need to be revised to reflect the changes in the standards. The proposed revisions are included as Appendix 2 to this report. An AC to assist in the interpretation of the criteria contained within the proposed rule, particularly a rational analysis method to define the CTI for go-around, would be beneficial but not a condition to publishing the new / revised standard.

How does the proposed standard compare to the current ICAO standards?: The proposed standards are consistent with, but more detailed than the ICAO standards.

Does the proposed standard affect other harmonization working groups?: Yes, FTHWG.

What is the cost impact of complying with the proposed standard?:
The proposed standards offer more flexibility and reflect currently accepted practice in compliance with the current standards as augmented by the issuance of special conditions. There should be a reduction in certification cost.

Does the working group want to review the draft NPRM prior to publication in the Federal Register?: Yes.

In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process. Explain: Yes, the "Fast Track" process is appropriate for this project. The project is neither too complex nor too controversial to use the "Fast Track" process. However, due to the change in categorization of this project from category 1 (envelope) to category 3 (harmonize), additional time is needed to complete this task and coordinate a recommendation from the Power Plant Installation and Flight Test Harmonization Working Groups.

APPENDIX 1 Proposed Rule Change

§/JAR 25.904 : **Automatic performance reserve (APR) system.**
Each applicant seeking approval for an airplane equipped with an engine control system that automatically increases the power or thrust on the operating engine(s) either when an engine fails during a takeoff/take-off or during a go-around when an engine becomes inoperative either before or after the go-around is initiated must comply with the additional requirements of Appendix I of this part.

§/JAR 25 Appendix I: **Automatic Performance Reserve (APR) System**

I 25.1 *General.*

(a) This Appendix specifies additional requirements for airplanes/aeroplanes equipped with an engine control system that automatically increases thrust or power on the operating engine(s) either when an engine fails during a takeoff/take-off or during a go-around when an engine becomes inoperative either before or after the go-around is initiated, or both.

(b) With the APR system and associated systems functioning normally as designed, all applicable requirements of part 25/JAR-25, except as provided in this Appendix, must be met without requiring any action by the crew to increase thrust or power.

I 25.2 *Definitions.*

(a) Automatic Performance Reserve (APR) System. An APR system is defined as a system that automatically increases thrust or power on the operating engines(s) either when an engine fails during a takeoff/take-off or during a go-around when an engine becomes inoperative either before or after the go-around is initiated. For the purpose of showing compliance with the requirements in this appendix/Appendix, the APR system comprises all elements of equipment necessary for the control and performance of each intended function, including the engine control system and all devices, both mechanical and electrical, that sense engine failure, transmit signals, actuate fuel controls or power levers of the operating engines(s) to achieve scheduled thrust or power changes, and furnish cockpit information on system operation.

(b) Critical Time Interval. The critical time interval for an APR system that automatically increases thrust or power on the operating engine(s) after an engine fails is defined as follows:

(1) For takeoff, the critical time interval is between one second before reaching V_1, and the point on the takeoff/take-off flight path with all engines operating where, assuming a simultaneous engine and APR system failure, the resulting flight path thereafter intersects the flight path determined in accordance with §/JAR 25.115,

at not less than 400 feet above the takeoff/take-off surface. This time interval is shown in Figure 1.

(2) For go-around, the critical time interval is defined as 120 seconds. A shorter time interval may be used if justified by a rational analysis.

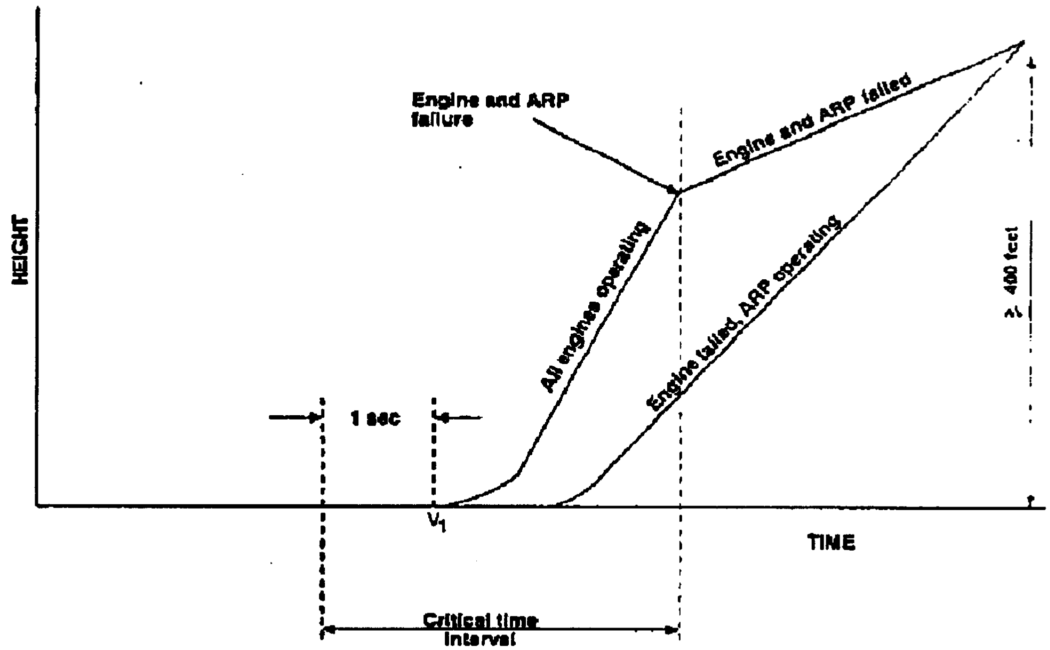


Figure A

I 25.3 *Performance Requirements.*

(a) All applicable performance requirements of part 25/JAR-25 must be met after failure of the critical engine at the most critical point during a takeoff or go-around, as applicable, with the APR system functioning.

(b) The propulsive thrust obtained from each operating engine after failure of the critical engine during take-off, or during a go-around, as applicable, used to show compliance with the one-engine-inoperative climb requirements of §/JAR 25.121(a), (b), and (d), as applicable, may not be greater than the lesser of–

(1) The actual propulsive thrust resulting from the initial setting of power or thrust controls with the APR system functioning; or

(2) 111 percent of the propulsive thrust resulting from the initial setting of power or thrust controls with the APR system failing to reset thrust or power and without any action by the crew to reset thrust or power.

I 25.4 *Reliability Requirements.*

(a) An APR system failure or a combination of failures in the APR system during the critical time interval:

(1) That prevents the automatic insertion of the intended takeoff or go-around thrust or power, as applicable, must be improbable.

(2) That results in a significant loss or reduction in thrust or power must be improbable.

(b) The concurrent existence of theAPR system failures regulated in section (a) above and an engine failure during the critical time interval must be extremely improbable.

(c) The inadvertent operation of the APR system must be remote or to have no more than a minor effect.

(d) The safety analysis must include consideration, as applicable, of an APR system failure occurring after the time at which the flight crew last verifies that the APR system is in a condition to operate until the end of the critical time interval.

I 25.5 *Thrust or Power Setting.*

(a) The initial thrust or power setting on each engine at the beginning of the takeoff roll or go-around, as applicable, may not be less than either of the following:

(1) That required to permit normal operation of all safety-related systems and equipment dependent upon engine thrust or power lever position; or

(2) That shown to comply with the applicable airplane controllability and engine operating characteristics requirements if thrust or power is increased from the initial takeoff thrust or power to the maximum available takeoff thrust or power at any point in the takeoff, or the initial thrust or power used for go-around to the maximum available go-around thrust or power at any point in the go-around, as applicable.

(b) For approval of an APR system for go-around, the thrust or power setting procedure must be the same for go-arounds initiated with all engines operating as for go-arounds initiated with one engine inoperative.

I 25.6 *Powerplant Controls.*

APPENDIX 1 Proposed Rule Change

(a) In addition to the requirements of §/JAR 25.1141, no single failure or malfunction, or probable combination thereof, of the APR system, including associated systems, may cause the failure of any powerplant function necessary for safety.
(b) The APR system must be designed to:
  (1) Permit manual decrease or increase in thrust or power up to the maximum available takeoff/go-around thrust or power through the use of the normal thrust or power levers.;
  (2) Provide a means to verify to the flightcrew before takeoff and before beginning an approach for landing, as applicable, that the APR system is in a condition to operate; and
  (3) Provide a means for the flightcrew to deactivate the automatic function, unless it can be shown that such a means is unnecessary for safety. This means must be designed to prevent inadvertent deactivation.

I 25.7 *Powerplant Instruments*

In addition to the requirements of §/JAR 25.1305:
(a) A means must be provided to indicate when the APR system is in the armed or ready condition; and
(b) If the inherent flight characteristics of the airplane do not provide adequate warning that an engine has failed, a warning system that is independent of the APR system must be provided to give the pilot a clear warning of an engine failure during the takeoff or go-around, as applicable.
(c) Engine indications must provide sufficient information during the takeoff or go-around, as applicable, to show whether or not the engine is capable of achieving the maximum available thrust or power without exceeding engine limits.

APPENDIX 3 Current FAR Text

25.904 Automatic Takeoff Thrust Control System

Each applicant seeking approval for installation of an engine power control system that automatically resets the power or thrust on the operating engine(s) when any engine fails during the takeoff must comply with the requirements of Appendix I of this part.

APPENDIX I

I 25.1 *General*

(a) This appendix specifies additional requirements for installation of an engine power control system that automatically resets thrust or power on operating engine(s) in the event of any one engine failure during takeoff.

(b) With the ATTCS and associated systems functioning normally as designed, all applicable requirements of Part 25, except as provided in this appendix, must be met without requiring any action by the crew to increase thrust or power.

I 25.2 *Definitions*

(a) *Automatic Takeoff Thrust Control System (ATTCS).* An ATTCS is defined as the entire automatic system used on takeoff, including all devices, both mechanical and electrical, that sense engine failure, transmit signals, actuate fuel controls or power levers or increase engine power by other means on operating engines to achieve scheduled thrust or power increases, and furnish cockpit information on system operation.

(b) *Critical Time Interval.* When conducting an ATTCS takeoff, the critical time interval is between V_1 minus 1 second and a point on the minimum performance, all-engine flight path where, assuming a simultaneous occurrence of an engine and ATTCS failure, the resulting minimum flight path thereafter intersects the Part 25 required actual flight path at no less than 400 feet above the takeoff surface. This time interval is shown in the following illustration:

[Illustration]

I 25.3 *Performance and System Reliability Requirements*

The applicant must comply with the performance and ATTCS reliability requirements as follows:

(a) An ATTCS failure or a combination of failures in the ATTCS during the critical time interval:

(1) Shall not prevent the insertion of the *maximum approved takeoff* thrust or power, or must be shown to be an improbable event.

APPENDIX 3 Current FAR Text

(2) Shall not result in a significant loss or reduction in thrust or power, or must be shown to be an extremely improbable event.

(b) The concurrent existence of an ATTCS failure and an engine failure during the critical time interval must be shown to be extremely improbable.

(c) All applicable performance requirements of Part 25 must be met with an engine failure occurring at the most critical point during takeoff with the ATTCS system functioning.

I 25.4 *Thrust Setting*

The initial takeoff thrust or power setting on each engine at the beginning of the takeoff roll may not be less than any of the following:

(a) Ninety (90) percent of the thrust or power set by the ATTCS (the maximum takeoff thrust or power approved for the airplane under existing ambient conditions);

(b) That required to permit normal operation of all safety-related systems and equipment dependent upon engine thrust or power lever position; or

(c) That shown to be free of hazardous engine response characteristics when thrust or power is advanced from the initial takeoff thrust or power to the maximum approved takeoff thrust or power.

I 25.5 *Powerplant Controls*

(a) In addition to the requirements of § 25.1141, no single failure or malfunction, or probable combination thereof, of the ATTCS, including associated systems, may cause the failure of any powerplant function necessary for safety.

(b) The ATTCS must be designed to:

(1) Apply thrust or power on the operating engine(s), following any one engine failure during takeoff, to achieve the maximum approved takeoff thrust or power without exceeding engine operating limits;

(2) Permit manual decrease or increase in thrust or power up to the maximum takeoff thrust or power approved for the airplane under existing conditions through the use of the power lever. For airplanes equipped with limiters that automatically prevent engine operating limits from being exceeded under existing ambient conditions, other means may be used to increase the thrust or power in the event of an ATTCS failure provided the means is located on or forward of the power levers; is easily identified and operated under all operating conditions by a single action of either pilot with the hand that is normally used to actuate the power levers; and meets the requirements of § 25.777(a), (b), and (c);

(3) Provide a means to verify to the flightcrew before takeoff that the ATTCS is in a condition to operate; and

(4) Provide a means for the flightcrew to deactivate the automatic function. This means must be designed to prevent inadvertent deactivation.

I 25.6 *Powerplant Instruments*

APPENDIX 3 Current FAR Text

In addition to the requirements of § 25.1305:

(a) A means must be provided to indicate when the ATTCS is in the armed or ready condition; and

(b) If the inherent flight characteristics of the airplane do not provide adequate warning that an engine has failed, a warning system that is independent of the ATTCS must be provided to give the pilot a clear warning of any engine failure during takeoff.

APPENDIX 4 Current JAR Text

25X20 Applicability

(c) If the aeroplane is equipped with an engine control system that automatically resets the power or thrust on the operating engine(s) when any engine fails during take-off, additional requirements pertaining to aeroplane performance and limitations and the functioning and reliability of the system , contained in Appendix I, must be complied with.

APPENDIX I

I 25.1 General

(a) This Appendix specifies additional requirements and limitations for aeroplanes equipped with an engine_control system that automatically resets thrust or power on operating engine(s) when any engine fails during take-off, and for which performance credit is limited to that of paragraph 25.3(b) of this Appendix. When performance credit is not so limited, Special Conditions will apply.

(b) With the ARP system and associated systems functioning normally as designed, all applicable requirements of JAR-25, except as provided in this Appendix, must be met without requiring any action by the crew to increase thrust or power.

I 25.2 Definitions

(a) *Automatic Reserve Performance (ARP) System.* An ARP system is defined as a system which automatically resets thrust or power on the operating engines(s) when any engine fails during take-off. For the purpose of the requirements in this Appendix, the ARP system comprises all elements of equipment necessary for the control and performance of each intended function, including all devices, both mechanical and electrical, that sense engine failure, transmit signals and actuate fuel controls or power levers of the operating engines(s) to achieve scheduled thrust or power increases, the engine control system and devices which furnish cockpit information on system operation.

(b) *Critical Time Interval.* When conducting an ARP takeoff, the critical time interval is between one second before reaching V_1, and the point on the gross take-off flight path with all engines operating where, assuming a simultaneous engine and ARP system failure, the resulting flight path thereafter intersects the gross flight path, determined in accordance with JAR 25.115, at not less than 400 feet above the take-off surface. This definition is shown in the following figure:

[Illustration]

I 25.3 Performance requirements

All applicable performance requirements of JAR-25 must be met with the ARP system functioning normally as designed, except that the propulsive thrust obtained from each operating engine after failure of the critical engine during take-off, and the thrust at which compliance with the one-engine-inoperative climb requirements in JAR 25.121(a) and (b) is shown, must be assumed to be not greater than the lesser of–

(a) The actual propulsive thrust resulting from the initial setting of power or thrust controls with the ARP system functioning normally as designed, without requiring any action by the crew to increase thrust or power until the aeroplane has achieved a height of 400 feet above the take-off surface; or

(b) 111 percent of the propulsive thrust which would have been available at the initial setting of power or thrust controls in the event of failure of the ARP system to reset thrust power, without any action by the crew to increased thrust or power until the aeroplane has achieved a height of 400 feet above the take-off surface.

Note 1. The limitation of performance credit for ARP system operation to 111 percent of the thrust provided at the initial setting is intended to—

(i) Assure an adequate level of climb performance with all engines operating at the initial setting of power or thrust controls, and

(ii) Limit the degradation of performance in the event of a critical engine failure combined with failure of the ARP system to operate as designed

Note 2. For propeller-driven aeroplanes, propulsive thrust means the total effective propulsive force obtained from an operating engine and its propeller.

I 25.4 Reliability requirements

(See JAR 25.1309 and AMJ 25.1309)

(a) The occurrence of an ARP system failure or a combination of failures in the ARP system during the critical time interval which—

(1) Prevents the insertion of the required thrust or power, must be shown to be Improbable;

(2) Results in a significant loss or reduction in thrust or power, must be shown to be Extremely Improbable.

(a) The concurrent existence of an ARP system failure and an engine failure during the critical time interval must be shown to be Extremely Improbable.

(b) The inadvertent operation of the ARP system must be shown either to be Remote or to have no more than a minor effect.

I 25.5 Thrust or power setting

The initial setting of takeoff thrust or power controls on each engine at the beginning of the take-off roll may not be less than the lesser of:

(a) That required to permit normal operation of all safety-related systems and equipment dependent upon engine thrust or power lever position; or

(b) That shown to be free of hazardous engine response characteristics when thrust or power is increased from the initial take-off thrust or power level to the maximum approved take-off thrust or power.

APPENDIX 4 Current JAR Text

I 25.6 Powerplant controls

(a) *General*
(1) In addition to the requirements of JAR 25.1141, no single failure or malfunction, or probable combination thereof, of the ARP system, including associated systems, may cause the failure of any powerplant function necessary for safety.
(2) The ARP system must be designed to perform accurately its intended function without exceeding engine operating limits under all reasonably expected conditions.
(b) *Thrust or Power Lever Control.* The ARP system must be designed to permit manual decrease or increase in thrust or power up to the maximum thrust or power approved for use following engine failure during take-off through the use of normal thrust or power controls, except that for aeroplanes equipped with limiters that automatically prevent engine operating limits from being exceeded, other means may be used to increase thrust or power provided that the means is located in an accessible position on or close to the thrust or power levers; is easily identified and operated under all operating conditions by a single action of either pilot with the hand that is normally used to actuate the power levers.
(c) *System Control and Monitoring.* The ARP system must be designed to provide
(1) A means for checking prior to take-off that the system is in an operable condition; and
(2) A means for the flight crew to deactivate the automatic function. This means must be designed to prevent inadvertent de-activation.

I 25.7 Powerplant Instruments

(a) *System Control and Monitoring.* A means must be provided to indicate when the ARP system is in the armed or ready condition.
(b) *Engine Failure Warning.* If the inherent flight characteristics of the aeroplane do no provide adequate warning that an engine has failed, a warning system which is independent of the ARP system must be provided to give the pilot a clear warning of any engine failure during take-off.

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APPENDIX 2 Proposed Existing Advisory Material Change

AC 25-13, "Reduced and Derated Takeoff Thrust (Power) Procedures"

Replace paragraph 5b with the following:

"b. Relevant speeds (V_{EF}, V_{MC}, V_1, V_R, and V_2) used for reduced thrust takeoffs are not less than those that will comply with the required airworthiness controllability criteria when using the takeoff thrust (or derated takeoff thrust, if such is the performance basis) for the ambient conditions, including the effects of an Automatic Power Reserve (APR) system."

Remove paragraph 5f(4) ("Are authorized for airplanes equipped with an ATTCS, whether operating or not, provided no performance credit is allowed for the one-engine-inoperative thrust increase.")

AC 25-7A, "Flight Test Guide for Certification of Transport Category Airplanes"

Replace "Automatic Takeoff Thrust Control System (ATTCS)" throughout paragraph 91 with "Automatic Power Reserve (APR)."

Replace paragraph 91(a)(1) with the following:

(1) Beginning in the 1970's, some manufacturers of turbojet airplanes elected to equip their airplanes with engine thrust control systems that automatically increased the thrust on the operating engine(s) when an engine failed. A similar system was later installed on some turbopropeller equipped airplanes.

Replace paragraph 91(a)(2) with the following:

(2) Takeoff performance credit was granted for APR based upon prescribed system functional and reliability requirements, and performance-related restrictions.

Remove paragraph 91(b)(4).

Replace paragraph 91(b)(5) (including (i) and (ii)) with the following:

(4) If the APR system is approved for use during reduced thrust takeoffs, the relevant takeoff speeds must meet the required controllability criteria of part 25 at the thrust level provided by operation of the APR. It must be demonstrated that the airplane has no adverse handling characteristics and the engines(s) must not exhibit adverse operating characteristics or exceed operating limits when the APR resets thrust on the operating engine(s).

(5) Takeoff with APR is not restricted when airplane performance is based on an approved derate thrust rating that has corresponding airplane and engine limitations approved for use under all weight, altitude, and temperature (WAT) conditions.

Advisory Circular

Advisory Circular Joint

Subject: AUTOMATIC PERFORMANCE RESERVE (APR) SYSTEMS	**Date:** 06 March 2002	**AC/ACJ No:** 25.904
	Initiated By:	**Change:** Draft 1

THIS DOCUMENT IS A WORKING DRAFT AND IS NOT FOR PUBLIC RELEASE

1. PURPOSE. This Advisory Circular (AC) *[Advisory Circular Joint (ACJ)]* describes acceptable means, but not the only means, for showing compliance with the requirements of §25.904 and Appendix I of the Federal Aviation Regulations (FAR) *[of the Joint Airworthiness Requirements (JAR)]*.

2. RELATED FAR *[JAR]* PARAGRAPHS.
§ 25.107, 25.121,25.901, 25.904 and 25.1309

3. APPLICABILITY. The requirements of Section 25.904 apply to powerplant installations incorporating an engine power control system that automatically resets the power or thrust on the operating engine(s) when any engine fails.

An APR system is defined as a system that automatically resets thrust or power on the operating engines(s) when any engine fails during a takeoff/take-off or go-around. For the purpose of showing compliance with the requirements of §/JAR 25.904 and appendix I/Appendix I to part 25/JAR-25, the APR system comprises all elements of equipment necessary for the control and performance of each intended function, including the engine control system and all devices, both mechanical and electrical, that sense engine failure, transmit signals, actuate fuel controls or power levers of the operating engines(s) to achieve scheduled thrust or power changes, and furnish cockpit information on system operation.

Appendix I addresses APR for both take-off and for go-around. It is not intended to require that both capabilities be provided. For example, if APR for go-around is not provided, the requirements related specifically to go-around are not applicable.

4. BACKGROUND.
The requirements related to this subject were originally introduced through special conditions for ATTCS, Automatic Takeoff Thrust Control System, which were limited to take off operations. These special conditions were introduced into part 25 as requirements (25.904 and Appendix I) at Amendment 25-62 in 1987. After the development of Amendment 25-62, FADEC controlled engines became the norm for Transport Category airplanes and the APR

systems, when implemented, were integrated into the basic engine control package, not installed as a separate device. These controls offered reliable one-engine-inoperative (OEI) performance reserves and could reliably offer these reserves throughout the flight envelope. These systems were not envisioned at the time of the rule introduction (Amendment 25-62) and hence the rule was amended (Amendment 25-XX) to address these systems.

From the mid-1990's on, the majority of aircraft being certificated with an APR system were being certified with special conditions allowing for the use of APR for go-around. In Amendment 25-62, the FAA had specifically not allowed the use of APR in this scenario as it was deemed less safe, because a flight crew would have to memorize both OEI and all engines operating power sets for go-around. Later systems allowed the use of a common power setting procedure for the OEI and all-engines-operating scenarios, with adequate system reliability to address the different power or thrust for OEI situations (as per take-off). Amendment 25-XX includes requirements applicable to APR systems intended for use during a go-around.

5. <u>SPECIFIC §25.904, Appendix I ASSESSMENT GUIDANCE.</u>

1. Reliability:

FAR 25 Appendix I *[JAR-25 Appendix I]* specifies minimum reliability levels for these automatic systems. Compliance with these reliability levels for the APR system itself, engine failures in combination with an APR system failure and other failure conditions, such as indications, which can arise as a result of introducing an APR system must be shown to meet specific criteria <u>in addition to FAR 25.901(c)/25.1309</u> *[JAR 25.901(c)/25.1309]*. The reliability assessment must include the applicable flight manual procedures (e.g. pre-flight, approach and/or daily checks), consider the mission length and exposure for potential dormant failures, and clearly define the assumptions used to define the critical time interval.

The term significant loss or reduction in thrust or power was defined in the pre-amble to this rule introduction, amendment 25-62. It states "'Significant loss or reduction in thrust or power" means an engine thrust loss that is more than two percent of the initially set total approved takeoff thrust for the airplane at existing ambient conditions.'

2. Indication:

Means to indicate that the system is available and functioning is traditionally done by dedicated indications of availability. An alternate means of indicating an APR system is armed and available, particularly with a system which is part of the basic engine control may be by indications of faults when the APR system or the engine control is not functioning (failed), has not passed it's built-in-test, or system integrity cannot be validated. System reliability between defined test or inspection intervals must be validated by a safety assessment. It is expected that some indication means exists on applying take-off power, either at take-off or go-around identifying that the system is available (or is not functioning properly). Should APR power be applied, either manually or automatically, this must be clearly identified to the flight crew by a means directly indicating APR power or thrust is being commanded.

APR systems must also provide means to clearly identify to the flight crew that operating limitations, noteably engine rotor speed(s) and gas temperture, will not be exceeded should APR power or thrust be required. This has been accomplished by:

- Defining & indicating 'soft' limits for normal take off which protect the 'hard'/ approved limits for maximum take off / APR thrust or power.
- Determining realtime the engine margins to the maximum approved limits and annunciate when a margin no longer exists (fully deteriorated).

The intent of this paragraph is to preclude latencies and ensure aircraft are not dispatched with beyond fully deteriorated engines.
The means selected must be validated.

Inhibit logic for aircraft with electronic crew annunciation systems should be considered in addressing crew workload scenarios during critical time intervals.

3. Performance credit

Performance credit for APR is limited to 111% of the normal take-off thrust or power set for take-off and go around. This limitation is intended to ensure a safe all-engines-operating takeoff. Without such a limitation, the all-engines-operating level of safety, which is set in the regulations by the one-engine-inoperative performance requirements, could be degraded.

4. Allowable APR Uptrim

Though performance credit is limited to 111% of initial power set, the actual engine power uptrim level may exceed that value. This allows some tolerance for initial power set and control uptrim power setting accuracy. Further it does allow controls to uptrim to maximum take-off power when using reduced power take-off's (ref:AC25-13). Engine and aircraft operating characteristics must be evaluated, as defined under the Thrust or Power Setting paragraphs, for the actual engine power uptrim level.

5. Means to Verify before take-off

The rule states 'The APR system must be designed to: ...(3) Provide a means to verify to the flightcrew before takeoff and before beginning an approach for landing, as applicable, that the APR system is in a condition to operate;'.
a) A means of compliance that has been accepted is that a verification means must be available should the flightcrew desire to check the system, but this check is not necessarily made mandatory. This means can be through a dedicated switch, pulling back one engine's power once the APR system is operative to confirm that APR is activated, or other approved means.
b) Further, the the system must indicate prior to take-off or approach for landing that it is functioning. Proper aircraft functioning with normal indications is an acceptable means, without necessarily requiring a dedicated APR armed indication, contingent upon all failures & significant faults being annunciated through cockpit messages. This should be substantiated by means of a system safety assessment. Confirmation of system health is by means of one or more of the following: cockpit annunciations, scheduled maintenance activities and/or aircraft flight manual checks.

6. Deactivation Means

The rule states that 'a means [must be provided] for the flight crew to deactivate the automatic function, unless it can be shown that such a means is unnecessary for safety.' This requirement is based on systems that may not be completely integrated into the rest of the engine control system, where it may be necessary from a safety standpoint to allow deactivation of this function. The rule recognizes that there may be circumstances where this means is not required or results in a decrease in safety. An example where disabling the automatic function would be unnecessary for safety would be an APR system fully integrated into the basic engine control such that should faults or failures that disable the APR function are equivalent to failures of the basic engine control. Such faults or failures would, however, require annunciation and /or fault accommodation. In certain extremely reliable designs which again must be part of the basic control, adding a dedicated means for deactivation might be shown to be a leading cause for APR failure during flight & /or lead to engine isolation / independence issues (one switch, both engines).

Systems that are not part of the basic engine control logic are required to have an independent dedicated means to deactivate the APR feature.

7. Required Power or Thrust

To maintain the same level of safety as airplanes without an APR system, it must be possible to manually increase or decrease the power or thrust up to the maximum power or thrust approved for the airplane. From a safety standpoint, there are situations other than engine failure where it may be necessary to use the maximum approved takeoff power or thrust (e.g., windshear recovery, terrain avoidance, collision avoidance). Also, in case the APR system fails to automatically reset thrust or power, the flightcrew must be able to manually reset it.

8. Thrust or Power Terminology

- The maximum approved takeoff thrust or power referenced in appendix I is the maximum takeoff thrust or power established for the airplane under part 25/JAR-25. It may not exceed the takeoff thrust rating limits established for the engine under part 33/JAR-33.
- The initial thrust or power that is set for takeoff with the APR system operative is generally referred to as normal takeoff thrust or power.
- The maximum available takeoff thrust or power is the thrust or power that the engine can achieve by the APR system or by manual means in accordance with aircraft flight manual procedures (vs the thrust or power that performance credit is based upon).
- The intended takeoff or go-around thrust or power is that which is anticipated to be achieved with the system working as per design. This value as a minimum is the value that aircraft performance is based upon, though may be greater.

9. Engine Failure Recognition

Engine failure recognition should be readily apparent to the flightcrew through the effect on airplane flight characteristics or aircraft / engine instruments. If it is not, a warning system independent of the APR system must be provided, i.e., the same engine failure indication source cannot be used to drive the APR system.

10. Critical time interval (CTI)

System reliability calculations are predicated on a determination of a "time at risk," i.e., a time period following the last verification that the system was serviceable up to the last point in time where the failure of that system would have a significant detrimental effect on the safety of the aircraft.

For APR systems used on take-off, this time at risk ends shortly after take-off at a point where simultaneous failure of an engine and the APR uptrim would still permit the aircraft to reach 400 ft above the take-off surface at the same point had the APR been functional throughout (see App I25.2(b)). At this point, sufficient time would have elapsed for flightcrew action to reset thrust on the operating engine(s) to maintain the part 25/JAR-25 flight path requirements. For the take-off case, the critical time interval is significant in the system reliability calculations as it forms a relatively high percentage of the total time at risk. This is because most APR system components are verified as serviceable by the crew shortly before commencement of take-off. Hence specific criteria are defined within the rule (see App I25.2(b)(1)).

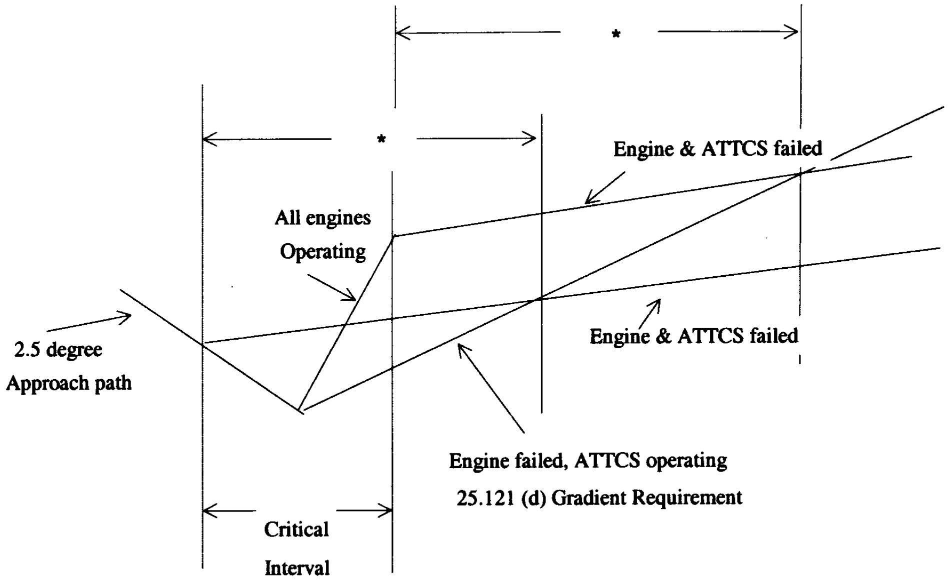
However, in the go-around scenario, the reliability calculations may be dominated by a much longer "time since last verification." For a number of critical components, this is the whole flight duration (typically an hour or more, depending on the aircraft). The few seconds added to this time by a calculated "critical time interval" for go-around at the end of the flight generally has a very minor effect on the overall time at risk and therefore on the calculated APR system reliability. Hence the CTI for go-around has been defined in the rule as a single value of 120 seconds. To cater for system designs where this conservative value would be unduly penalizing, the rule allows a shorter time interval to be used if justified by a rational analysis.

An accepted analysis that has been used on past aircraft certification programs is as follows:

(a) The critical time interval begins at a point on a 2.5 degree approach path from which, assuming a simultaneous engine and APR system failure, the resulting approach climb flight path intersects a flight path, originating at a later point on the same approach path, corresponding to the §/JAR 25.121(d) one-engine-inoperative approach climb gradient. The time interval from the point of simultaneous engine and APR system failure to the intersection of these flight paths must be no shorter than the time interval from V_{EF} to a height of 400 feet above the takeoff/take-off surface during a takeoff/take-off (ref. §/JAR 25.111(c)(4).

(b) The critical time interval ends at the point on an all-engines-operating go-around flight path from which, assuming a simultaneous engine and APR failure, the resulting minimum approach climb flight path intersects a flight path corresponding to the §/JAR 25.121(d) one-engine-inoperative approach climb gradient. The all-engines-operating go-around flight path and the §/JAR 25.121(d) one-engine-inoperative approach climb gradient flight path originate from a common point on a 2.5 degree approach path. The time interval from the point of simultaneous engine and APR system failure to the intersection of these flight paths must be no shorter than the time interval from V_{EF} to a height of 400 feet above the takeoff/take-off surface during a takeoff/take-off (ref. §/JAR 25.111(c)(4).

(c) The critical time interval must be determined at the altitude resulting in the longest critical time interval for which one-engine-inoperative approach climb performance data are presented in the Airplane Flight Manual.



* This time interval must be no shorter than the time interval from V_{EF} to a height of 400 feet during takeoff.

Figure A

FAA Action: Placed on the AVS “Do By Other Means” list, dated June 14, 2005.